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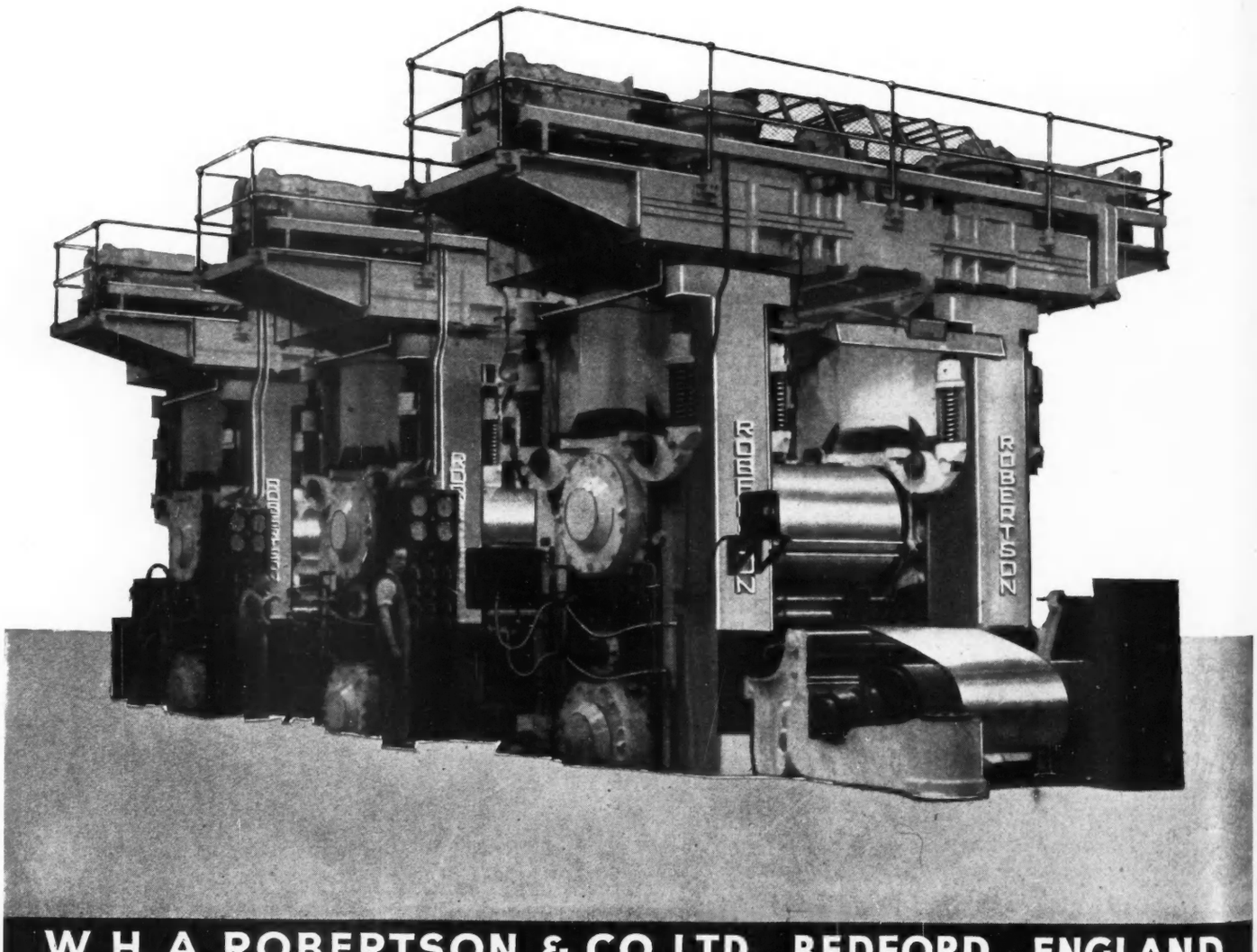

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SEMI-PERMANENT BRIDGES OVER THE RHINE AT MAINZ.

BEFORE the war there were three bridges across the Rhine in the neighbourhood of Mainz, which lies on the west bank of the river. Two of these were railway bridges: one, at the south side of the town, on the line to Frankfurt, connected Mainz with Gustavsburg, an industrial suburb lying on the opposite side of the river from the main town; the other, situated farther north, carried the Mainz-Wiesbaden railway. This latter bridge was in two sections, its centre portion passing over an island known as Peters-Aue. The road bridge connected Mainz with Kastel, a residential suburb on the east bank of the Rhine. At the time of the unconditional surrender of Germany, which became operative on June 5, 1945, the two railway bridges had been completely wrecked, but the road bridge, which had been extensively damaged, had been repaired sufficiently to carry traffic. In addition, a temporary railway bridge had been constructed, and there were two military bridges, both built under heavy fire, for assault and support purposes in the final stages of the war. One of these was a 1,896-ft. long steel bridge, which was constructed in 24 hours; this is believed to be the longest floating tactical bridge built during the war. The other was a floating Bailey bridge, constructed in 72 hours.

After the termination of hostilities, instructions were issued that bridge installations of a more permanent nature should be provided. Mainz lies in the American occupation zone, and the work was assigned to the 343rd Engineer General Service Regiment, which was attached to the American Seventh Army and had much experience in bridge construction. Before work had proceeded very far, it became necessary to transfer the 343rd Regiment to another area, and the job was taken over and completed by the 333rd Engineer Special Service Regiment. Survey and testing by army engineers of the structures then existing showed that while both the temporary railway bridge and the repaired road bridge were in service, it was doubtful if either of them would be strong enough to withstand the high water and ice flows which are usually experienced at Mainz during the early spring, and it was decided that the most satisfactory procedure would be to build an entirely new road bridge rather than to attempt further to patch up the old one. The same decision applied to the railway bridge. The two original bridges of this type were completely wrecked and beyond repair, and although it might have been a simpler job to provide a new bridge at the crossing over Peters-Aue island, this site would not have served the purpose which was of immediate importance. The southern bridge lay on the main line connection to Berlin, which constituted one of the chief traffic arteries of the country; both the railway and road bridges were necessary to provide proper communications for the American occupation forces in Germany. The new railway bridge which has been built is illustrated in Figs. 2 and 3, on this page, the former showing the Paris-Berlin express crossing, and the latter the destroyed bridge, on the right.

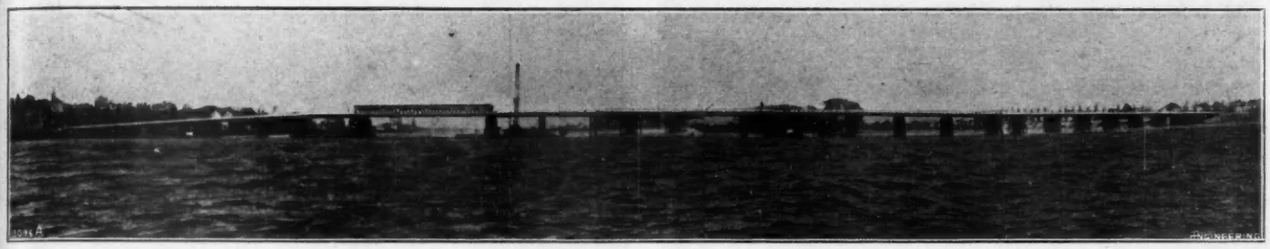

FIG. 1. GENERAL VIEW OF COMPLETED ROAD BRIDGE.

FIG. 2. RAILWAY BRIDGE, SHOWING PARIS-BERLIN EXPRESS CROSSING.

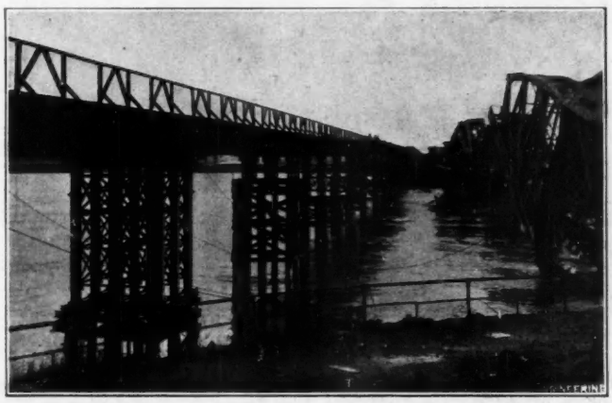

FIG. 3. RAILWAY BRIDGE, LOOKING FROM MAINZ SIDE OF RIVER.

A general view of the new road bridge after completion is given in Fig. 1.

Although the two new bridges are entirely independent structures, situated more than a mile apart, their construction, in some respects, constituted a single job. In both cases work was put in hand in late August, 1945, and they were both formally opened for traffic on January 18, 1946. When orders for the construction of the bridges were issued on August 25, 1945, an immediate start was made in the preparation of designs and the assembly of equipment and material. Many difficulties and discouragements were encountered. The design of the road bridge in particular had constantly to be modified to suit the material available; similar changes, but of a less drastic type, were also necessary for the railway bridge. A large part of the labour forces employed, in both cases, consisted of German prisoners of war and German civilians. Additional skilled labour was provided by the employment of the 500th German Service Unit, a bridge-construction unit which had been captured intact with its equipment in the African campaign. A total of 1,300 United States Army engineers were employed with about 1,200 Germans on the railway bridge and approximately 750 Germans on the road bridge. Something over a million man-hours were expended in the construction of the railway bridge and about half a million on the road bridge.

The railway bridge, which has been named the General Marshall Bridge, after General George C. Marshall, is an all-welded steel structure, 3,163 ft. long, with 42 spans of lengths varying from 70 ft. to 90 ft., and a 54-m. Roth Wagner truss. The latter provides a navigation passage with a width of 165 ft., and a vertical clearance of 29·3 ft. at high water. The bridge carries a single railway track on a uniform grade of 0·4865 per cent. There is a 6-deg. 21-min. curve on the Mainz approach. At the Gustavsburg side, 16 piers, situated on dry land, consist of light pre-fabricated steel trestles supported on wood piles capped by a reinforced concrete slab. The wood piles, of which there are an average of 17 for each pier foundation, were driven with a drop hammer carried by a 4-ton Bucyrus-Erie crane mounted on crawler tracks. The operation is illustrated in Fig. 4, on page 146. The piles were driven to an average depth of 27 ft. and had a minimum safe bearing of 15 tons, the test load being applied to them after driving. The concrete caps are 4 ft. thick and were poured inside timber shuttering. The footing beams at the top of the cap, to which the steel trestles are bolted, are set 4 in. deep in the concrete. They can be seen in the view of the completed land pier given in Fig. 5, on page 146.

Eight land piers, four on each bank, and 18 river piers, are built up of tubular steel piling. They are carried by 400-mm. tubular steel piles driven to a minimum safe bearing of 25 tons and with penetrations of up to 65 ft. For the river piers, the outer piles are driven with a batter to ensure greater stability. The piles were driven by an air hammer handled by a crane on a barge. An early stage in the driving of the piles for the river piers is illustrated in Fig. 6, on page 146. A later stage of the work, when the piles had been driven for almost the full length of the bridge, and some of the piers were approaching completion, is shown in Fig. 7, on page 146. The piers are formed by upper extensions of the driven piles, the extensions being made by welding a sleeve to the driven pile and fitting the extension over it. The operation of placing one of the extensions in position is shown in Fig. 8, on page 147, and Fig. 9, on the same page, shows an extension being welded in position after being placed in the sleeve. A completed weld is illustrated in Fig. 10, page 147. After the whole of the extension piles for a pier were in place, they

SEMI-PERMANENT BRIDGES OVER THE RHINE AT MAINZ.

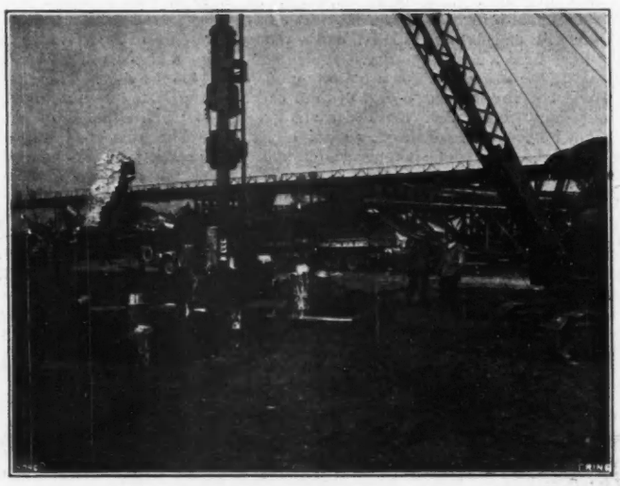

Fig. 4. Driving Piles for Land Piers of Railway Bridge.

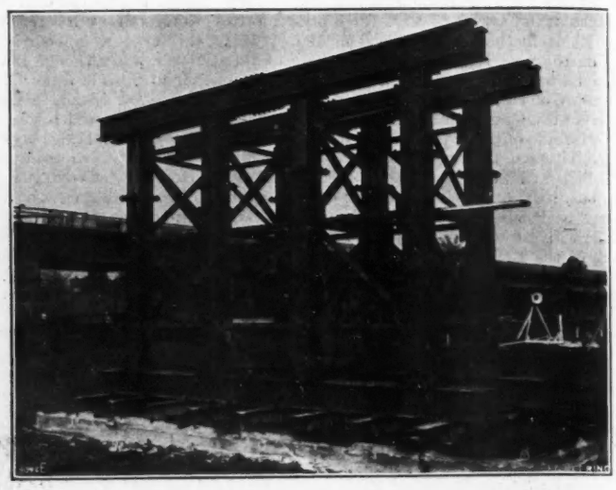

Fig. 5. Completed Land Pier for Railway Bridge.

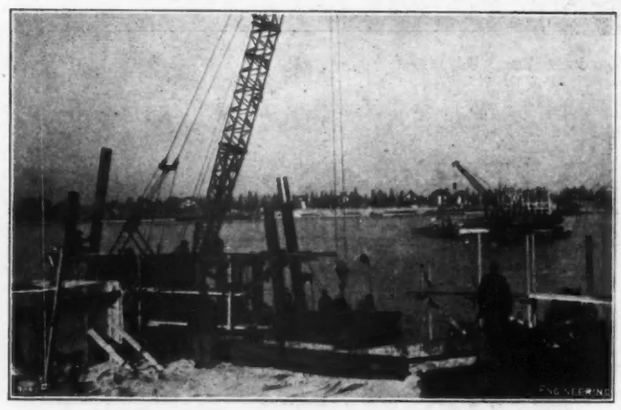

Fig. 6. Driving Piles for River Piers of Railway Bridge.

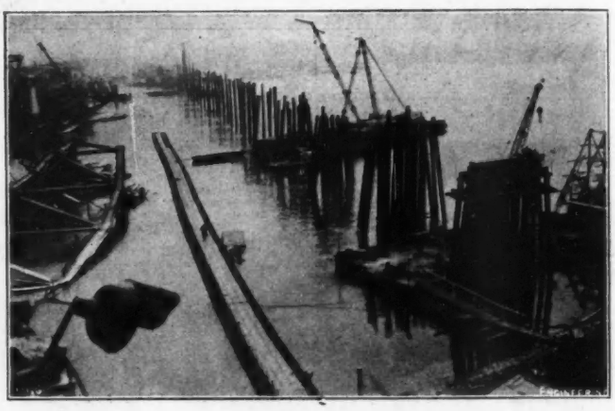

Fig. 7. River Piers for Railway Bridge under Construction.

were cut off to the correct elevation and the capping, built-up of 400-mm. and 600-mm. wide-flanged beams, was welded in place. When the piles were being driven, timber forms were used to hold them in correct alignment. One of the piers with the capping nearly completed is shown in the foreground of Fig. 7, on this page. The piers were completed by welding cross-bracing, made either of angle or channel, between the extension piles. The river piers are provided with timber fenders to act as ice breakers.

The full length of the bridge, apart from the navigation span, is built up of wide-flanged beams 1 m. deep. A view of the Gustavsburg land piers with the beams in position is reproduced in Fig. 11, opposite, and an early stage in the erection of the river spans is shown in Figs. 12, on page 156. For the land piers, the beams were handled and placed in position by a crawler crane, and for the river piers by a crane mounted on a barge. The beams were welded to the pier cappings and angle or channel cross-bracing was welded between them. In all, 3,069 cross-brace ties were used in the construction of the bridge. The heaviest piece of erection work in the building of the bridge was the placing of the 54-m. Roth Wagner truss which weighs 280 tons. It was built on a 500-ton cement barge moored about a mile from the bridge site. When completed, the truss was floated to a near-by position and lifted and placed by two steam-operated floating cranes. The operation, which was completed in about four hours, is illustrated in Fig. 13, on page 156. Timber decking, to which the railway track was spiked, was used throughout the length of the bridge. The following quantities were used in the construction of the railway bridge: 1,527 tons of metre beams, 400 tons of light steel trestling, 1,570 tons of 400-mm. tubular steel piling, 8,100 linear feet of wood piling, 85,000 ft. of timber, 540 cubic yards of concrete, and 300 tons of steel rails. As a final reference to the illustrations of the railway bridge, it should be said that the apparently undamaged viaduct to be seen in the background of Figs. 4 and 5, carries part of the line from Mainz to Worms, which lies on the west side of the Rhine.

The road bridge, named the General Patch Highway Bridge, after the late Lt.-Gen. Alexander M. Patch, who commanded the Seventh United States Army throughout the European campaign, is 1,972 ft. long and has 27 spans ranging in length from 50·7 ft. to 82 ft. and, in addition, a 54-m. Roth Wagner truss over the navigation channel. The clearance below this span at high water is 29·3 ft., similar to that of the corresponding span of the railway bridge. To obtain this clearance, the bridge has a 3·5 per cent. grade on the Mainz side of the navigation span and one of 1 per cent. on the Kastel side. Mainz is on the left-hand side of the general view of the completed bridge given in Fig. 1, page 145.

The bridge is an all-welded steel structure of generally the same type as the railway bridge. It is carried on steel-pile piers, the number of piles per pier varying from 14 to 39. They were driven to a minimum bearing of 25 tons and with penetrations ranging up to 84 ft. An early stage in the construction of the piers is illustrated in Fig. 14, on page 156. The wooden template used for spacing the piles and holding them at the correct relative inclinations can be seen in this illustration. The stringers consist of wide-flanged beams ranging from 482·6 mm. to 1,000 mm. in depth, and the number per span ranges from five to eleven. The decking is built up of 8 in. by 8 in. transverse joists, covered with two layers of 3-in. planking, the lower layer being laid longitudinally and the upper diagonally. A view of the deck during construction is given in Fig. 15, on page 156. The roadway is 24 ft. wide, with a 2-ft. sidewalk at each side, and the bridge is designed to carry 40 tons with two-way traffic in operation and a 70-ton load for one-way traffic.

The main departure in erection methods from those followed in the case of the railway bridge was that the Roth Wagner trusses, of which there are two, side by side, were built in position on piled timber falsework, instead of being constructed on barges and lifted into position. The building of these trusses was put in hand at an early stage of the work and before the connecting spans and piers were in position. A view of one of the Roth Wagner trusses in position on the timber falsework is given in Fig. 16, on page 156, and Fig. 17, on the same page, shows the deck of the completed trusses. The road bridge contains 1,800 tons of structural steel; 1,162 tons, equivalent to 31,000 linear ft., of 400-mm. steel piling; 800,000 ft. of timber; and 15,000 ft. of wood piling.

The building of these two bridges in four months required the assembly of large quantities of constructional plant. Much of this was obtained from other engineer units, which were inactive at the time, or from local depots, but large quantities had to be transported by rail or road from depots in France and Belgium. At the peak of the work,

SEMI-PERMANENT BRIDGES OVER THE RHINE AT MAINZ.

FIG. 8. PLACING EXTENSION PILE IN POSITION ON DRIVEN PILE.

FIG. 9. WELDING EXTENSION PILE ON DRIVEN PILE.

FIG. 10. COMPLETED WELD BETWEEN DRIVEN AND EXTENSION PILES.

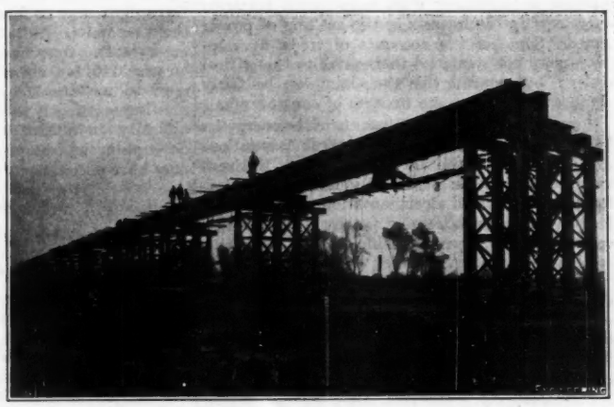

FIG. 11. GUSTAVSBURG LAND PIERS WITH SPANS IN POSITION.

13 floating pile-drivers and five pile-drivers operated by portable cranes, were in use, together with two drop hammers. There were two tugs, 23 boats of various kinds, 100 25-ton pontoons, 28 air compressors, four concrete plants and 86 electric welders. Work was carried on continuously on a two- or three-shift basis, three shifts being used on critical operations, such as pile driving, welding and concreting. At one time, the whole of the 86 welding machines, with 150 operators, were employed on the railway bridge. To obtain these operators, it was necessary to select from over 250,000 prisoners of war.

Much of the material required for the construction of the bridges was located at a distance in Germany or in depots in France and Belgium; some had to be transported over distances of 600 miles. As at an early stage it became evident that the delivery of material would be the controlling factor in the date of completion of the bridges, a special expediting section, led by technical officers, was set up. One incident in particular illustrates the difficulties encountered in connection with the supply of material. A train load of tubular steel piling was forwarded from the dump at Hanau to Kassel, instead of to Kastel, obviously owing to confusion between the names. Kassel is 300 miles from Mainz and by the time the shipment had been traced, it was found that the piles had been used for repairing the Kassel water-supply system. Substitute material was ultimately obtained from rolling mills in the British zone. As a final comment, it may be suggested that although these are described as semi-permanent bridges, in view of the industrial position in Germany and Europe generally, they are likely to be found still in service many years hence.

SHEET AND STRIP METAL USERS' TECHNICAL ASSOCIATION.—The annual general meeting and autumn conference of the Sheet and Strip Metal Users' Technical Association, 49, Wellington-street, London, W.C.2, will be held in London, on September 25 and 26. A banquet will be held on the evening of the second day.

INSTITUTE OF TRANSPORT.—The Council of the Institute of Transport have made a number of awards in respect of papers submitted during the 1946-47 session, and also in connection with the 1947 examinations. These include the Railway Companies Association Awards of 40*l.* to Mr. J. R. Pike, 40*l.* to Mr. A. E. Sewell, and 10*l.* to Mr. R. L. F. Woodhouse; the Road Transport (Passenger) Medal and 15*l.* to Mr. C. E. Lee; the Bristol and White Smith Student Prize and 10*l.* to Mr. K. B. Crosby; the Dock and Harbour Authorities Association Awards of 15*l.* to Mr. W. A. Flere, and 5*l.* to Mr. A. F. Hares; the Sir Alfred Read Examination Prize and 25*l.* to Mr. R. I. Cowan; the Inland Waterway Carriers' Award of 10*l.* to Mr. A. Hayman; the "Modern Transport" Award of 5*l.* to Mr. A. G. Yates; the Institute Shipping Award of 15*l.* to Mr. C. H. Minett; the Institute 1944 Award of 15*l.* to Mr. L. D. Kitchin; the Graduate Award of 15*l.* to Mr. J. H. C. Payne; and the Student Award of 10*l.* to Mr. K. J. Lee. The associate-membership examination prize of 20*l.* for the first place has been awarded to Mr. W. H. Stebbings, and of 10*l.* for the second place to Mr. W. Lawrence. The graduateship examination prize of 10*l.* for the first place has been awarded to Mr. W. A. Lake, and of 5*l.* for the second place to Mr. D. J. Wilkinson.

LITERATURE.

The Story of the Engineers. By DR. JAMES B. JEFFERYS. Lawrence and Wishart, Limited, 2, Southampton-place, London, W.C.1. [Price 10*s.* 6*d.*]

IT is a moot point whether history should be written by those who have been intimately concerned with its evolution or by more detached observers whose personal interest is solely in producing a précis of documentary evidence. In the latter case, the historian may easily err through ignorance, but, in the former, he may err quite as easily and extensively through failure to appreciate that most questions have at least two sides. The purpose of this book, which is to commemorate the centenary, in 1945, of what is now the Amalgamated Engineering Union, is an admirable one, however it may be regarded; but the book itself would be best described merely as a contribution to the study of its subject, for its claims to be considered as veritable history are too extensively vitiated by inaccuracy and lack of judicial balance to be taken seriously. In part, these shortcomings may be explained by the "wartime difficulties of evacuated libraries and the destruction of irreplaceable documents," to which reference is made in the preface; and in part, perhaps, by the possibility that the author, as an official of the Union, may not have had that full access to the documents bearing on both sides of contentious matters which is essential to the achievement of a true perspective.

It is not easy to deal both briefly and adequately with a work which attempts to pack into 300

pages some 150 years not only of union history, but of technical development also. It starts with Maudslay's "go-cart" of 1794-5 and culminates with the production of 100,000 aircraft during the recent war; both notable in their respective ways, of course, but somewhat outside the ostensible purpose of the book, except, in the case of the slide-rest, as marking the beginning of the multiplication of machine tools which, 45 years later, had resulted in a sufficient accumulation of engineering tradesmen to form the basis of the modern A.E.U. Having thus fixed his "end points," however, the author seems to have subdivided the period in a rather casual manner into four sections, 1800-1852, 1852-1892, 1892-1920, and 1920-1945. The only apparent reasons for selecting these dates are that 1852 was the date of the Oldham strike; 1892 was a year of similar trouble on the Tyne; 1920 was the year of the emergence of the present Amalgamated Engineering Union from the former Amalgamated Society of Engineers; and 1945 was a quarter of a century after that event. The story might have flowed more smoothly without these arbitrary divisions, which tend to emphasise the generally "bitty" style of the whole. Within each period an attempt is made to record the technical progress of the industry in separate chapters, while the history of the various unions is dealt with in other chapters. On the technical side, the narrative suffers from over-compression, a rather uncritical acceptance of some familiar sources and apparent unfamiliarity with more recent research, and a certain carelessness in the spelling of proper names. Some of the accounts of trade developments may not commend themselves to the critical reader; but against this the claim can be fairly advanced that many are matters of controversy.

It must be admitted that, in spite of the energetic, if overdue, efforts of the British Records Association, the Council for the Preservation of Business Archives, and other historically-minded organisations, the industrial documentation of the Nineteenth Century is extremely patchy; and for this reason alone it is impracticable to join issue with Dr. Jefferys on many matters without requiring at least as much space as he has taken. The later periods, however—certainly, from 1920 onward—are well within the memory of most of the senior personnel, at any rate, who are still engaged in the engineering industry. Whether such readers of this book happen to be on the trade-union side or that of the organised employers, they should realise without any prompting that, during a period of such vast economic and social upheaval, it simply could not be possible that the unions were always so unassailably right as this account purports to show, or that the employers could be always so completely wrong. All experience goes to suggest that there were probably rights and wrongs on both sides at most times, but the casual reader would never suspect as much if he relied on Dr. Jefferys's historical guidance alone, and it may be questioned whether Dr. Jefferys appreciates sufficiently that events are often more effectively in charge of situations than are the mere human participants.

Of the more notable reticences in the book, much more might have been said (and legitimately expected to be said) of how the A.E.U. went into the early Trades Union Congress, passed to the General Federation of Trade Unions, then back to the T.U.C. in 1905, only to leave it again in 1915 and return in 1918. Similarly, a note of its many ins-and-outs with the Confederation of Shipbuilding and Engineering Unions would have added something to the general historical knowledge. The story of the York Memorandum, likewise, is passed over much too lightly and the Central Conference organisation is another important topic which merits more attention than it has received; after a mention that the references to it had increased from 15 in 1898 to 33 in 1914, the subject is dropped. It seems somewhat pointless, too, to reproduce twice a particularly unhappy cartoon of 1922; once, as noted in the index, on page 222, and again, but not indexed, on page 234.

In the record of the years 1920-45, the name of Sir Allan Smith is mentioned on only two occasions, and that of Sir Alexander Ramsay not at all. The agreement on Joint Production Committees, in 1942, is recorded, but without reference to the many resolutions passed by A.E.U. branches in 1940, pledging undying opposition to the idea. As the account stands, on page 254, the ordinary reader might suppose that this agreement was forced from unwilling employers by an anxious union. The reference to Award 326,* on page 256, also claims that the merging of a portion of the national bonus into the base rate was in response to a demand of the Union and was resisted by the Engineering Employers' Federation; actually, this award (except for one minor clause) was an imposition by the Government of an offer which the employers had made spontaneously during previous negotiations. The unions were not seeking in 1943, as is claimed in the book, to "simplify a most complicated wage structure"; indeed, at one stage the A.E.U. leaders were forced to reject the offer that the employers had made voluntarily, and which the National Tribunal confirmed. Such discrepancies as these are typical of a number which any impartial critic, who had lived observantly through the period, could detect in these later chapters.

Towards the end of the war, one of the leading officials of the A.E.U. published (by private enterprise) a work purporting to explain Union-Federation agreements. The Union then produced a rule which forbade such individualism. The present book, apart from being an official centenary volume, is fortified not only with a foreword by the principal officers of the A.E.U. but with a reproduction of all their signatures in facsimile, and a frontispiece of their several portraits (not all of which, however, are recent). One more item may be mentioned: on page 146, but not noted in the index, is a reference to a "pro-Federation paper, *Engineering*," existing apparently in the 'nineties. We find some difficulty in identifying the periodical by this description and suspect that the Federation, too, may have encountered that difficulty.

Precision Workshop Methods. By H. J. Davies. Edward Arnold and Company, 41-43, Maddox-street, London, W.1. [Price 40*s.* net.]

This book was published originally in 1935, and in this second edition a new chapter has been added on surface finish, and a number of recent references appended to the extensive bibliography. Other books on this subject have appeared in recent years, but the excellence of Mr. Davies's work is such that it deserves to have attention drawn afresh to its merits. It is unusual, in a book on this subject, to find not one catalogue illustration of instruments or machines on the market, which raises the question that so many authors fail to ask themselves: What does the reader of a serious text-book on this subject want? Surely, the answer must be, a clear and logical explanation of the principles underlying the design and use of such machines. With the knowledge so gained, the reader can then turn to manufacturers' catalogues with real confidence and the ability to discriminate between similar machines in the light of the particular application envisaged. The book deals throughout with principles and basic methods, and is illustrated with line drawings which show clearly and without irrelevant detail the points made in the accompanying text. It is a corollary of this method of treatment that, after more than ten years, the book is in no sense out of date, and little correction has been necessary.

Another advantage of dealing with principles, rather than examples of their application by manufacturers of machine tools and measuring equipment, is that a far wider field can be covered without the risk of superficiality. Mr. Davies deals not only with the methods used in making tools, jigs and fixtures of extreme accuracy, but also with limit systems, machine-tool tests, and machinability, each in a separate chapter which constitutes an excellent essay on its subject. In the chapter on machinability, for instance, he gives a most interesting description of the extensive research work on the subject, notably by Herbert, Coker, and Stanton and Hyde. Another point of note is the felicitous introduction of historical information at various points, as in the discussion of limit systems; indeed, it is a matter for consideration whether the historical approach is used sufficiently by engineering writers. It is too often forgotten that an explanation of how modern methods came to be evolved is frequently the most effective, and certainly the most readable and interesting, explanation of how they operate. In no field can this be more true than in the evolution of workshop methods of ever-increasing accuracy, and these historical touches in Mr. Davies's book are so refreshing that they might well be extended more consistently over the whole subject matter.

Most of the chapters deal with methods used principally in the tool-room, or originating there, but those on gear cutting, screw cutting, and grinding are more directly related to production practice. In these chapters, a knowledge of the usual machine tools and processes is assumed and the reader will not find any detailed discussion of how the actual machines are designed. He will, however, find many fresh ideas in the comparisons which the author makes of the effects on the accuracy and other qualities of the product of applying the basic principles in different ways according to the different types of machine in use.

* Engineering, vol. 156, page 314 (1943).

Elementary Applied Aerodynamics. By Professor Paul E. Hemke. Prentice-Hall, Incorporated, 70, Fifth-avenue, New York, N.Y., U.S.A.; and Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 26*s.* net.]

This American publication, sponsored in this country by Messrs. Constable, is essentially a student's class text-book, and covers ground that would be dealt with in a first course in aerodynamics, applied principally to aircraft design. It should appeal to both teachers and students in classes leading to the aeronautical subjects in the National Certificate and similar examinations, and might also form a useful introduction for university students who will eventually study the more scientific side of aeronautics. While there is nothing new in the subject matter, its method of presentation is different from any English text-books published up to the present. The work is explained in short chapters and illustrated with worked mathematical examples, a number of exercises being given at the end of each chapter. It is thus of direct help to a reader preparing for an examination, and could be used as an ancillary to the more scientific English books on aerodynamics, in much the same way as a tutorial class is held to emphasise points given in lectures. This use of it is encouraged by the author's liberal use of footnotes, referring the reader to the fuller and more scientific literature on the subject.

The first half of the book covers the more fundamental parts of the subject of fluid motion, the physical properties of air, and conventional units and dimensions. The rest deals, from the designer's point of view, with the properties of aerofoils, the effects of compressibility on their characteristics, aircraft performance, and propellers, and includes a useful chapter on the helicopter. Altogether, this is a book that may well be a useful companion to students of aerodynamics, serving both to emphasise points brought out in their lectures, and to give them practice in working examples such as they may expect to meet in their examinations. Now that the aeronautical subjects are beginning to crystallise into definite divisions, and various bodies are offering examinations in them, there should be a field for this type of book in each division, written particularly from the standpoint of English practice.

Consumption of Non-Ferrous Metals in Britain.—Detailed figures of the consumption of non-ferrous metals in the United Kingdom during the second quarter of 1947, covering zinc, lead, tin, cadmium and antimony, have just been issued by the Directorate of Non-Ferrous Metals, Ministry of Supply. The total of the virgin zinc consumed during the second quarter of 1947 was 57,946 tons, as compared with 48,701 tons in the first quarter of the year. Corresponding figures for virgin lead were 40,237 and 42,535 tons; for virgin tin, 6,857 tons and 6,663 tons; virgin cadmium, 130 tons and 122 tons; and virgin antimony, 1,317 tons and 1,160 tons.

INDUSTRIAL PROBLEMS IN CZECHOSLOVAKIA AND ITALY.

ALTHOUGH commercial intercourse is increasing between Britain and the European countries which were overrun by Germany, and many British industrialists are now familiar with the conditions obtaining in France, Holland, Belgium and Scandinavia, the position farther to the east is less fully appreciated. We believe, therefore, that the following general survey of the position in Czechoslovakia and Italy, collated from the notes of an engineer who has returned recently from an extensive tour in those countries, may be of interest and, perhaps, of some value as a "background" contribution to a better understanding of the industrial situation in parts of Europe which are potentially better able than many to promote the recovery and stabilisation of European economy because of their high standard of engineering technique.

The study of the problems of Czechoslovak industry is very interesting. Many of these problems have been satisfactorily solved there which are still unsolved elsewhere and it may be possible to learn something from the successes or failures that have attended the solutions. The most acute trouble is a shortage of labour; this is critical because nearly three million Germans were expelled for political reasons, without regard to the labour market, while, for similar reasons, many executives had to be removed from key positions. An additional factor was, that during the German occupation, Czech universities and technical colleges were, to a large extent, forcibly closed down or employed for German educational purposes, so that it became difficult for the young Czechs to study. Many key men were victims of the German occupation and a great number of specialists who settled abroad did not return to Czechoslovakia when the country was liberated. It is easy to see, therefore, that difficult problems had to be faced in the reorganisation of Czechoslovak industry, both nationalised and private.

Nationalisation of basic industry has added greatly to the complexities and the difficulty of finding suitable persons for executive duties. This is one of the main preoccupations of the present Czechoslovak Government and is intensified by the confiscation of property from Germans, Hungarians and their collaborators. During the war, some enterprises were too ready to collaborate with the enemy, and it would have been against the national interest to allow them to continue under the same ownership. Obviously, sorting out the collaborators was not easy, and the policy followed did not always work out exactly to schedule. Some key industries were nationalised without reference to size, including large undertakings such as power stations, iron and steel works, rolling mills, non-ferrous metal works—with the exception of those foundries which form integrated units, and the armaments industry; a large part of the chemical industry, including oil refineries, makers of artificial fibres, synthetic rubber and tyres, the pharmaceutical industry, and cellulose plants; sugar refineries; the cinema industry; and smaller plants such as those for engineering, glass, china, ceramics, and paper. Some branches of the wood industry, textile, clothing, leather goods (Bata), and food-processing plants come into this category if more than a certain number of employees (150 to 500, according to the type of industry) were employed. In all, about 2,200 enterprises, employing about 61 per cent. of the total available labour force (about 730,000 persons) were nationalised in Czechoslovakia, and these do not include the railways, which have been operated by the State for many years. Printing was not included in the nationalisation scheme. The number of nationalised enterprises was reduced considerably by amalgamations carried out to simplify production and planning from technical, administrative and commercial points of view, and to make possible extensive specialisation in production. It is understood that compensation will be paid to former owners except in cases where they were enemies or collaborators.

There is a considerable difference between State enterprises and those which are nationalised. Nationalised enterprises are independent legally-constituted organisations, administered by managing committees with a director at the head of each. Their organisation and administration conform as closely as possible to the conditions of association for private enterprises from the commercial and technical aspects. Side by side with the national industries, private enterprise continues and, in many cases, is strongly supported by Government encouragement.

As already mentioned, the main difficulty has been a shortage of skilled and unskilled labour, and the Czech Government therefore directed labour in a manner similar to that applied in the United Kingdom during the war. Every able-bodied person must work, and no one can quit his employment without the consent of the labour exchange or the approval of the local national committee. Absenteeism is liable to penalties, while overtime is strongly encouraged by giving a generous income-tax relief on the extra money earned. Output is encouraged by the payment of bonuses, and intensive propaganda is used to urge people to work harder. Miners enjoy special privileges and earn very high wages because, for this reason, their output is satisfactory. Generally, the people work well and there has been no major strike since the war ended, though local strikes sometimes occur and are not always due to wages disputes.

Whether the output in a particular enterprise is higher or lower than it was before nationalisation depends very much on the conditions in each case. In some plants the executive staff has remained intact and output is good, but in others considerable changes have been made in personnel and it is proving difficult to maintain reasonable efficiency. On the whole, the heavy engineering and metal industries work satisfactorily, because they have employed mainly Czech labour since before the war. In the glass, artificial jewellery, ceramic, and other industries, however, which employed many Germans, great difficulty is experienced in obtaining skilled labour and many plants are working at a low level of efficiency; several in the border districts have shut down altogether and are being dismantled. In small enterprises which run under national administration, output depends to a great extent on the administrator, and some of these officials have been removed from their posts because of incompetence. The Czechoslovak Government encourage the return of Czechs and Slovaks who have settled abroad, especially skilled workers, many of whom, including miners, have lived in other countries for years; for example, French glass factories are in difficulties because many key workers have returned to Czechoslovakia. Incidentally, it is interesting that Poland also encourages "re-emigration" and many Polish miners have left France to go back to Poland.

One great advantage enjoyed by Czechoslovakia at present is the ability to benefit from the technical and administrative experience of capitalist countries, as well as from that of the Soviet Union. Soviet technicians have not been idle, and have gained much knowledge and experience which is not sufficiently known outside their own country. Research work is carried out on a large scale and many technical problems which are still unsolved in other countries have been solved satisfactorily there. Many doctrinaire ideas on factory management have now been abandoned and new ideas have been adopted which have resulted in more efficient production. As a result of experience, Soviet economists have come to the conclusion that one man should direct and be fully responsible for each enterprise, and not be influenced by any committee. Experience has proved that it is better to have one director of average intelligence than the less certain direction of a number of persons, individually perhaps more capable, because a quick and clear decision is ensured by one definite line of thought, which is and will always be the basic condition for a successful enterprise.

Other problems which are causing difficulties in Czechoslovakia concern raw materials and transport. Coal is, perhaps, the only raw material which need not be imported; for most others, the country is dependent on imports. Difficulties of transport in Czechoslovakia and the neighbouring countries affect the supply of raw materials and their price. In the third quarter of 1946, the output of soft coal was about 85 per cent. of the output in the corresponding period in 1937, while the output of hard coal was about 109 per cent. of the 1937 figure. As the output of Silesia is no longer available and much of the brown coal is used for producing synthetic petrol, production is only just sufficient to meet the fuel requirements of the country. Generated electric power is 40 per cent. higher and the make of gas also is more than in pre-war years.

Unrra supplies have contributed greatly to the reconstruction of economic life and this help is much appreciated by the people. The Soviet Union was the principal importer of goods in 1946, followed by Switzerland, Sweden and Great Britain. The export figures are largest for Switzerland, followed by the U.S.S.R. and Germany. Britain was 12th on the export list. The principal classes of imports are iron ores (from Sweden, Russia and Yugoslavia); raw materials for the textile and chemical industries, including oils and fats; rubber, hides, tobacco, tannin, ball bearings, and certain foodstuffs. The principal exports are iron, engineering products, glass—of which three-quarters of the total production is exported—cotton, silk and linen, paper, sugar, malt and hops.

An ambitious two-year plan has been worked out for 1947 and 1948 which demands a great effort on the part of labour and management alike. It is too early to judge whether the individual targets of the plan will be reached, but a considerable amount of hard work is being put in to make the plan a success. The general objective is a 10 per cent. higher production in 1948 than in 1937, and a complete re-equipment of industry within three years. Definite production targets have been set for various important products and a great effort is being made to achieve or, if possible, to exceed them. It is admitted that the position is very difficult in some respects, because of the lack of skilled labour and the changes in executive staff, but it is hoped that these difficulties will be overcome as time goes on. The Government have been very successful in convincing the nation that harder work is necessary. From the technical point of view, there are few really new developments in Czechoslovakia, the endeavour being not so much to race ahead of developments in other modern industrial States as to increase the quality and the quantity of the goods produced; but, obviously, new trends are in no way ignored.

At the present time, in Czechoslovakia, 77 per cent. of the iron castings and 98 per cent. of the steel castings are produced in nationalised foundries; 21 per cent. of the foundries are nationalised and these produce 64 per cent. of all the iron castings; 28 per cent. have been confiscated and produce 13 per cent. of the castings, the 40 per cent. still in private hands produce 12 per cent. of the castings, 10 per cent. are in Slovakia and produce 8 per cent. of the castings, and the remaining 1 per cent., belonging to the Czechoslovak State Railways, produce 3 per cent. of the castings. Grouping the foundries according to size, it is found that 49 per cent. of them, of small size, produce 6 per cent., the 31 per cent. of medium-sized foundries produce 18 per cent., the large foundries, numbering 17 per cent., produce 42 per cent., and the largest foundries, 3 per cent. numerically, produce 34 per cent. of the total output. The privately-owned foundries are mostly small, having an average output of only 105 metric tons per annum. Their importance, however, cannot be judged only by their size, for some of these firms produce special castings of excellent quality, but, on the whole, these firms can rarely utilise their plant really efficiently. Foundries are considered large which have an output of 1,000 to 5,000 metric tons a year; the largest Czech foundries produce, on the average, 10,000 metric tons a year. The average annual production in Czechoslovakia is 850 metric tons of cast iron, against approximately 3,800 metric tons in America. The steel foundries present a different picture. There are fewer of them, but the units are bigger than in the case of iron foundries. The average output of a steel plant, in 1946, was 2,200 metric tons, but 67 per cent. of the total output is produced in four large plants, 30 per

cent. in 11 smaller plants, and the rest in three small plants. Open-hearth furnaces are used in some of the large plants; otherwise, high-frequency and arc furnaces are used almost exclusively. All steel-casting foundries are nationalised, and about 98 per cent. of those which produce steel ingots. Of the steel for forgings, 95 per cent. is produced in eight large foundries, and the remaining 5 per cent. in four small ones. Of the total output of ferrous castings, 80 per cent. is cast iron, 18 per cent. consists of steel castings, and 2 per cent. of ingots.

The two-year plan prescribes a total production of 300,000 metric tons, of which 70 per cent. would be cast iron, 18 per cent. steel, 2½ per cent. ingot steel, and 9½ per cent. is intended to suit requirements as they develop. The output of cast iron covers all domestic requirements, but the steel output is in excess of the country's needs, so that considerable quantities should be available for export. Some big foundries, especially Skoda and Vitkovice, are well equipped to produce steel castings of very large size. Skoda is at present engaged on an order for a 28,000-kW low-pressure turbine. The top casting, weighing 17,000 kg., has been completed and the bottom casting, of equal weight, should also be ready shortly. Recently, a crankshaft weighing 53 tons, forged in one piece, has been produced by Skoda.

(To be continued.)

NOTES FROM NORTH AMERICA.

THE United States Corps of Engineers have invited the New York engineering firm of Guy B. Panero to investigate the feasibility and cost of constructing and operating underground plants and storage sites. The studies are part of a long-range programme under the direction of the United States Army-Navy Munitions Board. Mr. Panero and his staff have had previous experience with the subject, having prepared a complete report for the United States Government on underground construction for German industry, based on an investigation made for the Army immediately after the cessation of hostilities. According to Lieutenant-General R. A. Wheeler, Chief of Engineers, these are two additional steps in the "protective construction" programme being conducted by the Corps for the potential protection of essential war plants against air raids. The overall programme will cover costs, as well as such technical data on existing foreign underground installations as are obtainable. Two types of underground plant sites will be considered during the investigation. The first are the existing mines, which were the subject of a previous survey made by the Corps of Engineers, to a considerable extent from records. Details of this "underground site survey" are not available to the public because of military security considerations, but it is known that it disclosed the availability of several hundred million square feet of usable underground sites. The current inquiry, as indicated above, will be to determine the practicability and cost of constructing and operating munitions plants and storage depots in this type of underground site. To be considered, a mine has to have more than 30,000 sq. ft. of usable floor space, a roof height of not less than 8 ft., and a reasonably level floor. Natural caves are not being considered at this time, as they are, in general, relatively small, irregular in character, and at a considerable distance from suitable transport facilities. The second type of site to be considered under the current investigation is the underground chamber purposely excavated to suit the plant or storage requirements involved. This type of site requires the study of the geological formations best suited to this purpose. Initially, a comparison will be made of the above-ground and underground costs of construction and operation of a chemical processing plant, involving large tanks and appurtenances, the generation of large amounts of heat and noxious gases, and having certain explosion hazards. The same line of investigation will be followed in regard to precision manufacturing plants, requiring exact temperature and humidity control. The physiological effects on persons working under these conditions will be studied also.

What is believed to be the first twin-engine transport-type helicopter is now being tested by the United States Army Air Forces. Known as the Kellett XR-10, the helicopter was designed to supply ground troops in areas inaccessible by other means. It is powered by two Continental engines, of 525 h.p. each, driving counter-rotating intermeshing three-bladed screws, both of which can be driven by either of the two engines. By employing counter-rotating rotors, the need for the customary tail rotor is obviated. The rotors are 65 ft. in diameter. The XR-10, it is stated, can carry ten passengers in addition to the pilot and co-pilot, and has a gross weight of about 11,000 lb. As an air ambulance, it can accommodate six wounded personnel on litters. Alternatively, a cargo of 2,000 lb. can be carried in lieu of passengers. The XR-10 has a maximum speed of well over 100 m.p.h. and, at a cruising speed of 90 m.p.h., has a range of nearly 350 miles. An innovation in its construction is a hatch in the underside of the fuselage, 2 ft. 9 in. wide and 4 ft. 4 in. long, provided with a hoist for picking up or lowering personnel or cargo from a hovering position. The helicopter was built at the North Wales, Pennsylvania, plant of the Kellett Aircraft Company.

Construction has begun on a water-power project, estimated to cost 19,000,000 dols., for the Hydro-Electric Power Commission of Ontario. The station is located on the Mississaga River in the Algoma district, 20 miles north of Thessalon and 50 miles east of Sault Ste. Marie, and will develop 56,500 h.p. The plant will generate current at 60 cycles, but there will be a frequency changer at Sudbury, Ontario, to provide a 25-cycles supply to the mining district of Sudbury-Nipissing. The main dam and power house will be built in a rocky gorge, 90 ft. deep, the river flow being temporarily diverted by means of a rock tunnel. The operating head will be 215 ft. A storage dam will be built 40 miles upstream at Rocky Island Lake, to regulate the river flow. This is the fifth major water-power project to be undertaken recently by the Commission, the other plants now under construction being at Des Joachims on the Ottawa River; at Stewartville on the Madawaska River, a tributory of the Ottawa; an extension of the new DeCew Falls plant on the Niagara escarpment; and a new plant on the Aguasabon River, north of Lake Superior.

The War Department has announced that a supersonic wind tunnel, designed to test the aerodynamic characteristics of ram-jet motors and other rocket motors is to be built under the supervision of the Corps of Engineers, U.S. Army, at the California Institute of Technology at Pasadena. The new tunnel, for which the expenditure of 2,384,000 dols. has been authorised, will be the first of its kind in the United States, where there is at present no other wind tunnel designed to test such missiles with the motors operating. The tunnel will be housed in a building 50 ft. by 150 ft., and the testing section of the tunnel will consist of a flexible nozzle with a cross-section 15 in. by 20 in., with which it will be possible to test models up to 3 in. in diameter. Three motor-driven air compressors, each driven by a 4,000-h.p. motor, will deliver a total volume of 171,000 cub. ft. of air per minute, at a velocity of 3,600 m.p.h. Tenders have been invited for the equipment, and the completion of the project is expected to take about 18 months. The California Institute of Technology was selected as the site for the new tunnel because the Institute is a permanent educational centre where advanced courses in jet-propelled missiles and their component parts are conducted by some of the foremost scientists in the country. The tunnel will be available for instructional purposes as well as to carry out fundamental research on guided missiles.

Leading civil-aviation officials of Mexico and of eight South American countries have begun a series of visits to the United States, where they will study under the direction of the Civil Aeronautics Administration and the American aviation industry. The first arrivals, in mid-April, were Señor Evaristo Lima, Director of Civil Aeronautics of Venezuela, and Dr. Luis Beltran Gonzalez, the legal adviser in civil-aviation matters to the Venezuelan Government. Both are studying the Federal Government's aviation activities with the object of adapting United States principles and methods to the needs of Venezuelan civil aviation. Upon completion of their study under the direction of the Civil Aeronautics Administration, they will visit the works of selected United States aircraft manufacturers, and, in conference with officials of the Aviation Division of the State Department, will discuss civil-aviation relations between the two countries. In the course of the summer, other high officials of civil aviation in Central and South America will arrive as guests of the United States Government for similar studies. The next group expected will be from Mexico and will be headed by Señor Javier Gonzalez Gomes, the Mexican Director of Civil Aviation. The delegation from Ecuador will include Colonel Ernesto Delgado, Director of Civil Aeronautics, and Dr. Falconi, legal adviser to the Director and to the Ecuadorean Government in aviation. Dr. Carlos Martinez, legal adviser in civil aeronautics in Peru, and Señor Federico Hilbck, President of the Government organisation operating the airports and airways of Peru, will arrive later to represent their country. The delegation expected from Chile will include Señor Juan del Villar, executive vice-president of the national airline, and Señor Eduardo Hamilton, legal adviser on aviation matters to the Chilean Government. Señor Julio Poussin, president and managing director of the Uruguayan airline, will represent that country. Señor Jose de la Reza, manager of Lloyd Aereo Boliviano, has been invited from Bolivia; Señor Mauricio Obregon, Director of Civil Aviation, is expected from Colombia; and Dr. Juan Raul Manzano, legal adviser to the Commercial Division of the Secretariat of Aeronautics, from Argentina.

A new navigational method which is expected to save up to 20 per cent. of the time required for long-range flights has been developed by the air weather service of the United States Army Air Forces. Research began more than three years ago on the new method, known as the "minimal flight path" when experienced pilots noted that, while the great-circle route was the shortest distance between two points on the earth's surface, excessive head winds and other atmospheric conditions might increase the time needed for such flights. A study was begun to determine the best method of utilising favourable wind conditions at various altitudes along the route of flights longer than 500 miles. It was discovered that deviations of as much as 200 miles from the great-circle route were worth while to take advantage of tail winds and so to reduce flying time. The science of preparing such a route has been developed to the point that an experienced weather office can prepare a flight plan in 30 minutes or less which will reduce the flying time for a flight across the United States from 10 to 20 per cent., and even greater economy in time has been realised in some cases. Mr. I. I. Gringorton, a former research technician on the staff of Brigadier General Donald N. Yates, commanding general of Air Weather Service, and Captain Kenneth S. Arrow have developed a mathematical formula which enables briefing officers to provide maximum time savings through use of the "pressure-pattern" flight plan. The new method differs from other pressure-pattern navigational systems, such as the single heading navigational method in which an average wind drift is determined for the flight course and a single magnetic heading maintained, allowing the aircraft to drift both to the right and left of course. The single-heading method is intended to permit the aircraft to reach its destination without changing course en route to compensate for wind drift. The minimal flight method enables the navigator to know the exact position of the aircraft at all times.

Experiments by the Army Air Force indicate that time savings with the minimal-flight method are greater than those obtained with the single-heading system. The system is, in effect, the application to air travel of the practice of masters of ocean-going sailing vessels of saving time on long voyages by taking advantage of ocean currents. Records compiled by the Air Weather Service from hundreds of observation stations throughout the world during the war have established the air mass movements, which follow an average seasonal path in the various continents, similar to the ocean currents, which vary with each change of season. Air Weather Service officers believe that the established air routes may be changed to take advantage of prevailing conditions when greater knowledge of the new method has been gained. Initial tests conducted by the Air Weather Service have indicated large savings of time by using the minimal-flight plan. A Boeing B-29 Super-Fortress of the Air Weather Service recently saved over 1½ hours in a flight from Washington, D.C., to March Field, California. A Douglas C-54 Skymaster used the new system in a flight from Hickam Field, Hawaii, to California, and landed considerably ahead of other aircraft which took off earlier. Weather officials believe that it is possible to prepare the minimal flight charts as much as 24 hours in advance with considerable accuracy. As study of air mass movement continues, it is thought that routes may be planned several days in advance.

MESSRS. COCHRANE AND SONS, LIMITED, Ouse Shipbuilding Yard, Selby, have orders on hand for 40 steam and motor-driven vessels, totalling 19,266 gross tons. They consist of 35 trawlers, two drifters, two tugs and one fishery-research vessel.

ROYAL INSTITUTION OF CHARTERED SURVEYORS.—The list of prize winners at the professional examinations of the Royal Institution of Chartered Surveyors, for 1947, has now been issued. The Penfold Gold Medal, Driver Prize and Constructive and Working Drawings Prize have been won by Mr. D. R. A. Heywood; the Penfold Silver Medal and a special prize, by Mr. F. P. Sadler; the Wainwright Prize, by Mr. Samuel Martin Smith; the Galsworthy Prize, by Mr. L. W. Perrins; the Institution Prize, by Mr. H. [illegible] Woolf; the Mellersh Prize, by Mr. A. Cowan; the Crawter Prize, by Mr. B. Gater; the Quantities Prize, by Mr. J. R. Chiswell; the R. Irwin Barr Prize, by Mr. S. A. Jack; the Hyman Marks Prize, by Mr. J. M. Hitchen; and the Julian Rogers Prize, by Mr. J. G. Hood. The Beadel Prize has been shared by Mr. R. H. Bell and Mr. F. G. Davy, D.S.O., D.F.C., and the John Gilchrist Prize by Mr. A. T. Johnstone and Mr. Samuel Martin Smith.

RECENT DEVELOPMENTS IN POWER-STATION PRACTICE.*

By F. W. LAWTON, M.I.Mech.E., M.I.E.E.

(*Concluded from page* 128.)

As regards switchgear, noteworthy developments, both in principle and in practice, have occurred. These can be traced to the need for increased breaking capacity to meet increased growth of system, combined with the ability to meet such requirements due to the large amount of information derived from switchgear-testing plants. The reduction in fire risks consequent upon several disastrous fires in power stations during the years shortly before the war, and the increased speed of operation to secure more rapid isolation of faulty plant and so limit the area affected by any breakdown, are other influencing factors. The need for limitation of fire risk has led to sharper segregation of sections, frequently involving physically separate switch houses associated with each large machine, together with physical separation of the control room. This has given rise to considerably increased costs in connection with buildings and cables, as well as additional switchgear units. The modern trend in switchgear is towards the factory-built metal-enclosed gear with its small bulk and superior safety features and ease of maintenance. The main improvements have been in the direction of reducing the oil content. This has been achieved largely by more efficient design of the arc-control devices. Designs employing horizontal or vertical isolation of the breaker unit are in general use and demonstrate the fundamental soundness of the principles incorporated in some of the original designs introduced by British manufacturers. Other types of metal-clad gear have been developed in which the breaker unit is fixed and isolation is effected by mechanically operated isolators. The main feature of this type of gear is the use of a single-break switch which still further reduces the amount of oil required. Considerable attention has also been given to reducing the amount of compound, or other inflammable material, in the insulation of 'bus-bars and connections. In one class of gear, which is in use at 33 kV and 66 kV, the compound-filled 'bus-bars have been replaced by a tubular condenser construction, and in another type the insulating spaces have been filled with Freon gas at a small positive pressure, thus eliminating all compound and all but a very small quantity of oil in the arcing chamber. A feature of this gear is that it is particularly adapted to the ring type of 'bus-bar with isolating features between units, whereby each part of every unit can in turn be subject to routine power-factor tests, with the remainder of the installation in normal commercial service. There is room for improvement in the design of switchgear to facilitate routine high-voltage testing of the cables connected thereto, as the magnitude and duration of the testing pressures required to satisfy the mains engineer frequently exceed the specified permissible conditions on the switchgear.

The most noteworthy advance is the development by all the leading British switchgear manufacturers of air-blast switchgear for service at the highest voltages and at the heaviest ratings. In some respects this was a natural development of the pneumatically-operated low oil content oil circuit breaker in which the use of compressed air was introduced to secure more rapid operation of the moving parts. The advantages claimed for air-blast switchgear are :—elimination of oil-fire risk, greater speed of operation, and mechanical simplicity. Most of the British manufacturers now have a limited number of air-blast breakers in commercial service, but it is too early to say whether this type of breaker will ultimately supersede its oil counterpart.

The inherent mechanical simplicity of the air-blast breaker is, however, largely discounted by the extra complication of the pneumatic system, and at the present time the heavy costs which have been incurred in connection with research and development deprive the user of any economic advantage from the installation of such equipment. It seems clear, in fact, that the complexity and cost of the pneumatic equipment will confine the economic use of air-blast breakers to high ratings at voltages above 33 kV, but at this and lower voltages the relative advantages and disadvantages of the two types are matters of controversy.

Station auxiliary supply systems require switchgear operating at 400, 3,300, 6,600 or 11,000 volts, the essential requirements of which are : absolute dependability, minimum fire risk, and ability to operate satisfactorily under arduous conditions, frequently involving high air temperatures and the presence of moisture, steam, and coal dust. Many stations are equipped with auxiliary switchgear of the conventional oil-immersed metal-clad type and, in general, this equipment has given good service. The need for eliminating oil, however, partly on account of fire risk and partly on account of the maintenance and reconditioning necessary with frequent heavy-current operation, has led to intensive study of contact performance and the behaviour of arcs in air. As a result, air-break circuit breakers are now available which will deal with most present-day requirements on systems up to 3,300 volts. Economic considerations are against any further extension of the range to higher voltages, but for the heaviest current duty up to 3,300 volts contact systems have been evolved which are capable of dealing with direct-on starting of motors of large horse-power. Air-break switchgear of this type can be assembled in enclosed metal cubicle form with suitable isolating features and the overall size is little different from oil circuit breakers of equivalent rating. Air-break switchgear is thus eminently suitable for power-station auxiliary service and there is little doubt that in this sphere it will prove to be a serious competitor of oil-immersed switchgear in future stations.

To sum up, the present trends in power-station switchgear fall into three well-defined categories :—for the highest rupturing capacities, at voltages of 33 kV or above, the choice rests between minimum oil content metal-clad circuit breakers and air-blast breakers, the relative merits of which, from the economic angle, appear to be closely balanced at the present time. For medium capacity gear, at 11 kV or 33 kV, the oil circuit breaker of proved design has no serious competitor, but further detailed improvements are to be looked for in the reduction of inflammable material and improved maintenance facilities. For station auxiliary service an adequate range of air-break switchgear is now available which is deserving of careful consideration.

With machines of 30,000 kW and upwards now the rule rather than the exception, a greater uniformity in station layout is becoming apparent where site limitations are not the controlling feature. Where not more than two boilers for each turbo-alternator are installed, it is practicable to adopt a simple end-on arrangement of machines parallel to a single row of boilers. This arrangement is particularly convenient where pulverised-fuel fired boiler units are installed with electrostatic flue gas cleaning plant, and ensures a simple arrangement of steam and feed piping. The auxiliary bay containing the feed pumps, heaters and evaporators between the turbine room and boiler house is now generally adopted, but steam and feed pipes do not always seem to receive the consideration they deserve. In modern stations with high steam conditions it is of great importance to cater properly for high-pressure pipes, and a pipe bay between the auxiliary bay and the boiler house is now often arranged exclusively for these pipes, as by this means it is possible to avoid expansion bends which would be necessary otherwise due to lack of space.

The one-boiler, one-turbine arrangement is the simplest, but for machines exceeding 30,000 kW this involves pulverised-fuel firing owing to the large boiler sizes required. The end-on arrangement seems to predominate in later layouts; there are exceptions, notably Little Barford, which has four 30,000-kW turbo-alternators arranged transversely. There can be little doubt that during the last decade power stations are coming to be regarded as single composite machines, rather than a collection of different kinds of machines and boilers with different characteristics. In normal day to day operation it is difficult to take the fullest advantage of slight improvements in heat cycle or performance on any individual machine in a power station, due to the incidence of maintenance and the necessity for running adjacent machines on common steam and water mains. Uniform plant characteristics and heat-cycle conditions throughout are to be preferred in order to obtain stable and reliable operating results over long periods.

The general trend of power-station architecture, particularly during the last ten years, has been towards functional realism ; and modern power-station buildings more faithfully represent without ostentation the true purpose of the project—the generation of electric power. This tendency is indeed most commendable. The power-station building is no longer a hybrid product adorned by false and irrelevant ornamentations borrowed from mediæval or contemporary architecture, but is at length achieving a dignity born of its real purpose. There is some danger, however, that the Fine Arts Commission may insist on superficial architectural adornments. It is hoped, however, that this phase will pass and a new dignity will arise conformable with the true purpose of the project.

While the majority of power-station superstructures are of structural steel, reinforced concrete has been used at Preston, Cardiff, Carlisle and Hams Hall " B." With the relative steel and timber prices ruling in 1938, reinforced concrete was cheaper for a large building than structural steel. To-day, owing to the large increase in timber prices for shuttering, no financial advantage is likely if reinforced concrete is used. The superior fire protection of the latter in comparison with uncovered steel is the main advantage of this form of construction. Many engineers have objected to reinforced-concrete superstructures as being rigid and inflexible and incapable of ready alteration. Difficulty in arranging steam-pipe supports is yet another common objection. These difficulties do exist ; they are, however, not insurmountable. It is essential that extreme care should be exercised in the initial layout, that the superstructure should be practically independent of the plant, and that beams supporting pipes should be cored where necessary for this purpose. Beyond these simple precautions there is little else to prevent reinforced-concrete construction, the choice of which should stand or fall by economic considerations.

It is the duty of all power-station engineers to produce electricity as cheaply as possible with due regard to continuity of supply and plant availability. To put this principle into effect demands more personal courage and restraint than does the installation of experimental high-efficiency plants which enhance the personal reputation of the responsible engineer. The race for high efficiency is technically interesting and has been accelerated by the rising cost of fuel which has brought higher steam conditions within economic range. To construct an economic frame of reference, one of the most important figures to establish is the average load factor of the plant throughout its economic life, and it is surprising how widely opinions vary on this fundamental matter. It seems clear that until the optimum power-station efficiency is reached the load factors of existing plants will continue to fall throughout the life of the plant, and it would seem that any plant which requires a load factor of say 50 per cent. or more to justify it economically, is likely to be a financial failure, and will thus have the effect of increasing the average cost of electricity.

Recently, the author had to investigate the economics in the design of the new Nechells power station with due regard to the speed of construction. It was found that with the then prevailing fuel prices it did not pay to exceed 650 lb. pressure or 850 deg. F. at an average load factor of 40 per cent. There is as yet little reliable information regarding operation and maintenance costs and availability of plant operating with steam conditions exceeding 650 deg. to 850 deg. F. at the turbine stop valve. If, however, the same availability and the same operating and maintenance costs are assumed for this plant as for that in the 650 deg. to 825 deg. F. range, then the accompanying table shows the economic load factors which are necessary to justify installing different plant with varying fuel prices.

Cost per Ton coal (Calorific Value 10,400 B.Th.U. per lb. Gross).	Economic Load Factors assuming all charges other than coal and capital costs (1944 prices) are common.		
	650 lb. per sq. in., 825 deg. F., 28·5 in. Vacuum at Turbine.	900 lb. per sq. in., 900 deg. F., 28·5 in. Vacuum at Turbine.	1,200 lb. per sq. in., 925 deg. F., 28·5 in. Vacuum at Turbine.
35*s.*	Up to 56·4	Over 56·4 and up to 69·2	Over 69·2
40*s.*	,, 49·4	,, 49·4 ,, 60·6	,, 60·6
45*s.*	,, 43·8	,, 43·8 ,, 54·0	,, 54·0
50*s.*	,, 39·5	,, 39·5 ,, 48·5	,, 48·5
55*s.*	,, 35·8	,, 35·8 ,, 44·2	,, 44·2
60*s.*	,, 33·0	,, 33·0 ,, 40·4	,, 40·4
65*s.*	,, 30·3	,, 30·3 ,, 37·2	,, 37·2

Any increase in the cost of operation and maintenance or decrease of availability necessitated by plant operating with the higher steam conditions, will have the effect of increasing the load factors which are given as economic in the table. For example, an increase of 0·001*d.* per kilowatt-hour generated, which may be considered reasonable, in going from 650 lb. to 900 lb. per square inch, and 900 lb. to 1,200 lb. per square inch, would modify the above table by increasing the economic load factor with the first set of steam conditions and coal at 35*s.* a ton from 56·4 to 68 per cent. and with the third set of steam conditions from 69·2 to 88·2 per cent. In other words, if an average load factor of 40 per cent. over the life of the plant (*i.e.*, 20 years) is considered as a reasonable basis for design, then it is fuel price which determines the heat cycle and predicates a pressure of 650 lb. per square inch and a temperature of 825 deg. F. for fuel prices up to 55*s.* per ton ; of 900 lb. per square inch and 900 deg. F. for prices between 55*s.* and 68*s.*, and 1,200 lb. per square inch and 925 deg. F. for higher prices.

THE LATE MR. H. A. DRANE.—We regret to record the death of Mr. H. A. Drane, which occurred on Sunday, August 3, after an operation. Mr. Drane, who was only 55 years of age, was service manager to Messrs. Alfred Herbert, Limited, Coventry, and his whole career had been spent in their service. Prior to his appointment as service manager, he did a great deal of work on the design, development, application and servicing of Coventry die-heads and dies.

* Paper read before the annual convention of the Incorporated Municipal Electrical Association, at Bournemouth, on Tuesday, June 24. Abridged.

CENTRING MACHINE AND ELECTRONICALLY-CONTROLLED GRINDER.

MESSRS. A. A. JONES AND SHIPMAN, LIMITED, Narborough-road South, Braunstone, Leicester, have produced the new double-ended centring machine, a photograph of which is reproduced in Fig. 1, on this page. This machine, which is available in four sizes for shafts up to 24 in., 36 in., 48 in. and 60 in. in length, respectively, has been designed for centre drilling and countersinking both ends of a shaft at one setting, by a pair of combination drilling and countersinking tools. It consists of a machined bed, carrying the right- and left-hand spindle heads and the vices, mounted on two box columns, the latter being connected by sheet-metal panels to provide rigidity. Three jack screws in each column enable the bed to be set level. The spindle heads and vices may be adjusted to any position on the bed, to suit the length of the work, and are secured in place by T bolts in an angular slot running the full length of the bed. On tightening these bolts, the overhanging lip of the base of the head or vice is drawn up against the machined edge on the front of the bed and accurate alignment of all the movable parts is ensured.

Each spindle head is provided with its own motor, of 0·5 h.p., for driving the spindle, by a V belt, at a standard speed of 1,000 r.p.m., which is suitable for a W.S. 3 or W.S. 4 centre drill with mild steel. The belts are enclosed and provision is made for tensioning Other spindle speeds, between 500 r.p.m. and 5,000 r.p.m. can be provided if desired for special requirements. Each drill spindle is equipped with a three-jaw chuck and is mounted on ball bearings in a steel quill fitted with a spring return. The rear end of the spindle has four splines to take the drive from an independently mounted pulley running on ball bearings, and the feed motion of the spindle is given by rack and pinion gear operated by a hand lever, which can be adjusted to the most convenient working position. To enable repetition work to be drilled to a uniform depth, an adjustable stop is provided. If simultaneous centring of both ends of a shaft is desired, as in the case of large batches of equal length, a special mechanism can be supplied for coupling together the feeds of both heads.

The work is held in a pair of two-jaw self-centring vices having hardened steel interlocking V jaws. They are operated by a right- and left-hand screw, which is protected against the entry of chips, and adjustments are provided for maintaining alignment in the event of wear. The usual coolant system, consisting of a tank, pump, piping and splash guards, can be supplied if required, the tank and pump being housed between the metal panels of the bed; a door in the front panel gives access. The switchgear is accommodated in the columns and consists of push-button operated contactor gear, with thermal overloads in all three phases and no-volt release, and a switch-fuse isolator. All internal wiring is complete up to the isolator and the electrical equipment of the standard machine is suitable for a 380/440-volt three-phase 50-cycle supply. The capacity of the vice is for work from ¼ in. to 3 in. in diameter.

Fig. 2 shows the firm's universal precision grinding machine which is provided with electronic control of the workhead; the control cabinet, normally placed at the back of the machine, is shown on the left of the illustration. This equipment provides an infinitely-variable range of work speeds, from 36 r.p.m. to 360 r.p.m., and the workhead spindle can be stopped or started at any speed by push-buttons, a dynamic brake being fitted for stopping the work instantly. Alterations in spindle speeds are effected through the electronic-control equipment by a small rheostat on the front of the machine.

The control equipment, which is operated directly off the alternating-current supply, varies the speed of the direct-current motor on the workhead through a ratio of 10 to 1 by armature-voltage control, the shunt field being excited at constant voltage. A single-phase full-wave rectifier, using two B.T. 5 thyratrons, provides the armature current, while two U.U. 8 hard-valve rectifiers, connected in parallel, supply the field current. Automatic current limitation is provided to ensure that the armature current does not exceed the pre-determined value. The voltage drops in the armature, series field, interpole windings and brushes are automatically compensated by increasing the voltage across the motor terminals, thus, it is claimed, ensuring good speed regulation. A line contactor is provided, which, when closed, connects the armature to the thyratron circuit, and when open, connects the armature to the braking resistance. Either live-centre or dead-centre grinding can be carried out on the machine and a quick change from one to the other can be obtained by turning the knob, which can be seen on the front of the workhead, to either the "live" or the "dead" position.

CENTRING MACHINE AND PRECISION GRINDER.

MESSRS. A. A. JONES AND SHIPMAN, LIMITED, LEICESTER.

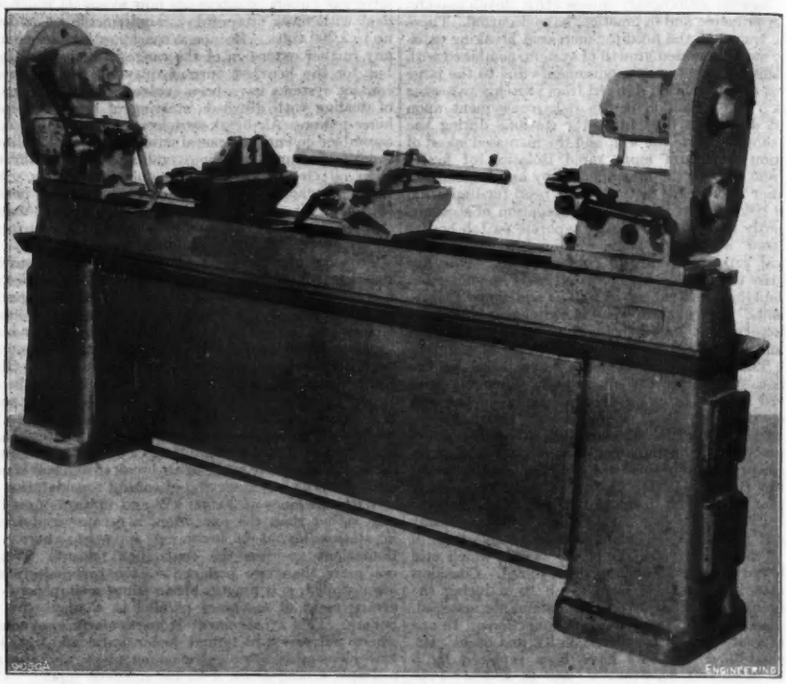

FIG. 1. DOUBLE-ENDED CENTRING MACHINE.

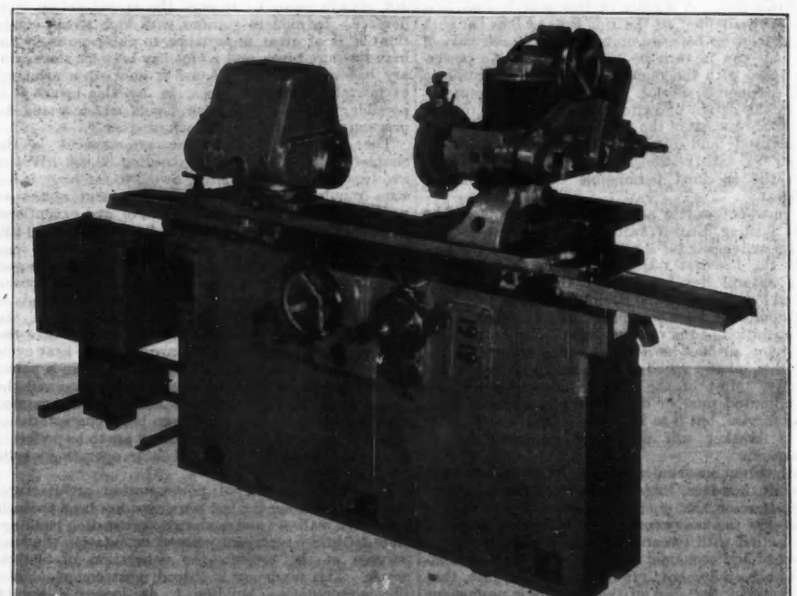

FIG. 2. GRINDING MACHINE WITH ELECTRONICALLY-CONTROLLED WORKHEAD.

BRITISH INDUSTRIES FAIR, 1948.—Next year's British Industries Fair will be held from May 3 to 14, at Olympia and Earls Court, London, and at Castle Bromwich, Birmingham. The London Section is organised by the Board of Trade, Export Promotion Department, 35, Old Queen-street, London, S.W.1. (Telephone: VICtoria 9040.) The Engineering and Hardware Section, at Castle Bromwich, is organised by the Birmingham Chamber of Commerce (under the auspices of the Board of Trade), 95, New-street, Birmingham, 2. We understand that forms of application for exhibiting space are now ready for issue.

OPENCAST COAL OPERATIONS.—According to statistics issued by the Ministry of Fuel and Power, upwards of 36 million tons of opencast coal have been produced since 1942, when this method of working began in this country. The present output, which is at the rate of 210,000 tons a week, constitutes about 5 per cent. of Britain's present coal production. Opencast operations are conducted on all the coalfields, except those of Somerset and Kent, and there are about 130 sites in operation at any given time. About 10,000 men are employed, they are drawn mainly from the civil-engineering industry, the remainder consisting of coal inspectors.

150-MVA SWITCHGEAR UNIT.

MESSRS. CROMPTON PARKINSON, LIMITED, LONDON.

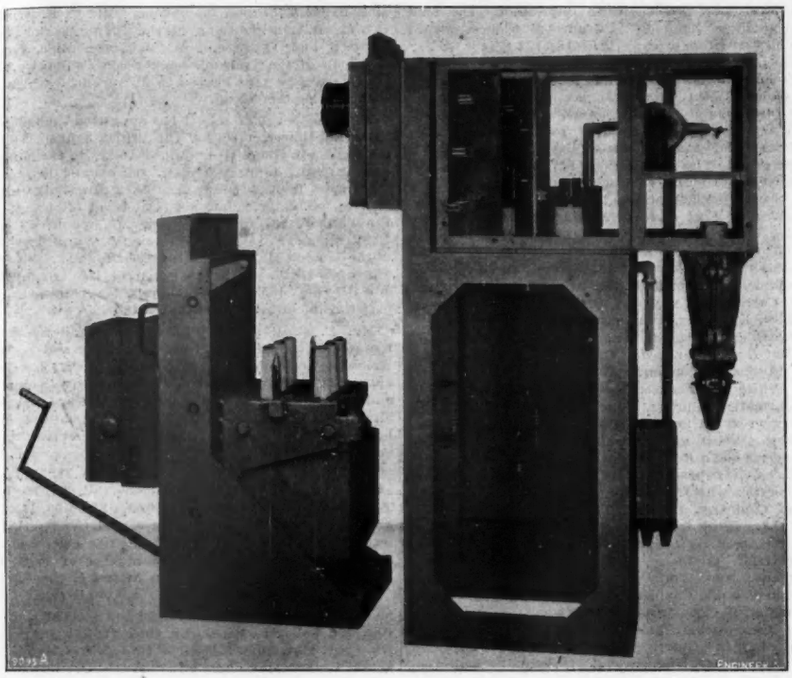

FIG. 1.

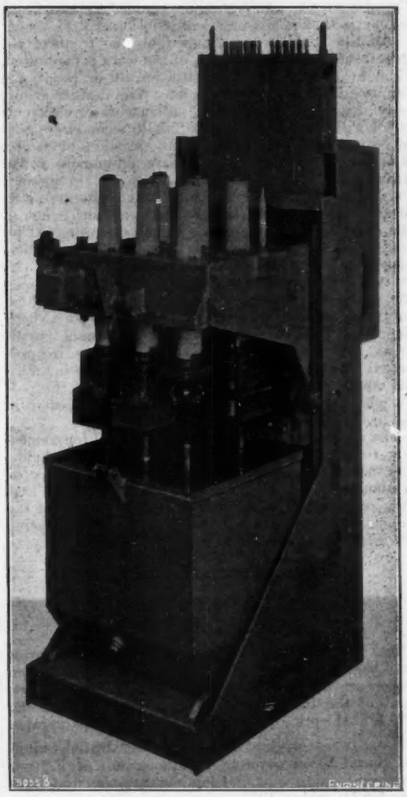

FIG. 2.

150-MVA SWITCHGEAR FOR DISTRIBUTION SYSTEMS.

THE ALA.1 class of switchgear, which has recently been introduced by Messrs. Crompton Parkinson, Limited, Electra House, Victoria-embankment, London, W.C.2, after development and proving at their Chelmsford testing station, has been designed with a view to reducing dimensions, simplifying maintenance, facilitating installation, and increasing safety. It is particularly intended for continuous use on supply undertakings and industrial-distribution systems. This unit is illustrated in Fig. 1, while another view, with the circuit-breaker withdrawn on to the truck and the tank lowered to show the arc-control devices is given in Fig. 2. In the latter illustration, one pot has been removed to show the contact assembly. The switchgear is rated for service voltages of 6·6 kV and 11 kV, the normal current rating being 600 amperes and the breaking capacity 150 MVA. To ensure ample thermal and mechanical factors of safety, however, the nominal ratings are well below the actual capacities attained on full-scale tests. As will be seen, the unit is completely metal-clad. The oil circuit breaker is provided with vertical isolation, while the 'bus bars are air insulated. The overall dimensions are 6 ft. 2 in. high, by 4 ft. 6½ in. deep, by 1 ft. 10½ in. wide.

The makers explain that these dimensions have been achieved partly by using a circuit breaker with arc-control devices of the side-blast baffle type. The self-aligning finger contacts, engaging with wedge-type moving contacts, which were formerly used, have been replaced by circumferentially-mounted members which form a socket for a rod contact. Adequate thermal capacity is obtained, partly owing to the design of the contact assembly and partly because the contact pressure is arranged to increase with the current. This feature naturally renders it necessary for the opening mechanism to be sufficiently powerful to separate the contacts under the worst possible conditions. It has been designed, therefore, to give consistent operation throughout the whole range of short-circuit currents. It can be actuated by any type of tripping gear. Closing can be effected manually by a solenoid, or by spring-operated mechanism.

The framework is a fabricated-steel structure, which is built up of specially-designed sections to combine rigidity with low weight. The truck is all-welded and runs on wheels mounted on roller bearings, which can be adjusted to ensure smooth and accurate alignment. The circuit-breaker unit is raised or lowered by a square-thread jack screw, which engages with a bronze self-aligning nut. This nut is operated through a ball-bearing gearbox, so that the effort required is reduced to a minimum. The stationary housing for the truck has two side frames to ensure rigidity and accurate location on the rails in the base. The isolating mechanism shutter gear is of the sliding-plate type which ensures that the 'bus bars are completely enclosed by earthed metal. These shutters can be padlocked in the closed position and, to enable feeder-earthing equipment to be used, an auxiliary shutter is provided so that the 'bus-bar orifices can be locked independently. These orifices are insulated with high-quality porcelain, which is cemented into machined castings. The 'bus bars are supported directly on the spout insulators and are braced by a Bakelite barrier between the units. As the secondary insulation is of Bakelite without auxiliary compound or taping, the joints can be inspected or extensions made in the minimum time.

The current transformers are located in a separate chamber to ensure flexibility and to enable the cable boxes or outgoing terminal positions to be arranged to suit the required disposition of the connections. Access to the transformers, insulators and connection joints can be obtained either from the top or the back of the unit. A separate terminal board is provided for the current-transformer secondaries. The instrument and relay panel is also a separate assembly. It comprises a raised panel, which is hinged to a secondary terminal compartment thus providing ample space for inspection, identification and tracing the secondary windings. This panel is mounted between extensions of the unit side frames and its height can be varied to suit the equipment specified. Mechanised interlocks are provided to ensure that when the truck is in position it is correctly registered and locked in the housing. The circuit breaker cannot be raised or lowered unless it is open; neither can it be raised unless the tank is fitted and bolted into position.

We understand that the unit has been proved by all the tests laid down in British Standard Specification No. 116, and that the insulation has been subjected to special over-voltage and corona tests. Complete units, including the current transformers, secondary plugs and sockets, and auxiliary equipment, have also been subjected to many tests with short-circuit currents in excess of those required for the issue of a certificate by the Association of Short-Circuit Testing Authorities. Proving in this way makes it possible to assign nominal ratings to the equipment which allow a liberal factor of safety, so that complete reliability with the minimum of maintenance is ensured.

50-KW RADIO-FREQUENCY HEATING EQUIPMENT.

IT is claimed that the radio-frequency heating equipment recently introduced by Messrs. Philips Lamps, Limited, Century House, Shaftesbury-avenue, London, W.C.2, will enable a large number of further operations and processes to be carried out by this method than could be dealt with formerly, owing to the increased power that it can provide. The equipment is designed to produce up to 54 kW measured at the work, and to permit true skin heating, as opposed to skin hardening, on areas of from 7 to 10 sq. in. A very large number of components which cannot be treated progressively, and in which the "single-shot" treatment with lower power results in heating to such a depth that the mechanical properties of the material are impaired, are thus brought within the scope of the process. In fact, we understand that the range of work with which it is possible to deal is as wide as that handled by the smaller generators now in use, but that the size of the specimen may be larger or the number greater. For example, ¾-in. diameter steel bar can be hardened to a depth of 0·03 in. at a rate of 2 ft. 2½ in. per minute if 20 kW is used, and at about 8 ft. per minute when the power is raised to 50 kW.

Owing to the variety of work the new generator has been designed to perform, current can be supplied at 400 kilocycles, 700 kilocycles and 1,000 kilocycles per second, in addition to the main frequency of 350 kilocycles per second. These alternative frequencies are selected by an off-load link system, their main purpose being to provide large steps in the output current, so that widely different loads can be matched to the generator. This enables the full power output of the generator to be made available for heating masses of metals with volumes varying over as wide a range as from $\frac{1}{10}$ cub. in. to 1 cub. ft. One of the most interesting features of the generator is that the output current can be varied continuously on load within the ratio of 2 to 1, thus giving a variation of 4 to 1 in power at the work. The makers consider that the usefulness of this feature in practice cannot be overestimated. For instance, the working coils do not have to be wound to very accurate limits to obtain the

maximum output, melting is easier and quicker, and, in particular, a great deal of tedious preparation in the way of pre-production experimental work can be eliminated. This on-load variation is obtained by inserting a variable step-down radio-frequency transformer between the valve anode and the tank of the Colpitts circuit. An advantage claimed for this transformer is that it has practically no losses.

All the controls are grouped on the front of the generator so that supervision of the work is facilitated. Remote control, either by push-button or pedal, can be provided. All the meters have 6 in. dials to ensure easy reading, and include an accurate electronic timer with a range of from 0·2 to 10 seconds. Special attention has been paid to the question of safety. The high-voltage components are oil-immersed and natural air cooling has been employed throughout, except on the rectifier valves. The circuits are interlocked to ensure that the switching is carried out in the correct sequence, and the valves are protected by water-flow switches and time delays. The valve-filament, valve-anode and high-tension transformer circuits are all provided with overload trips which open the contactors in 0·06 second. In addition, high rupturing capacity fuses are used to protect both the main and auxiliary circuits. The main circuit breaker, which has normal over-load releases, is interlocked with the two rear doors of the cubicle in which the equipment is housed to ensure safety of the personnel. An interference suppressor is connected in the incoming mains supply.

The standard model of heater is designed for connection to a 380/440-volt, 50-cycle three-phase circuit, and the maximum input is 93·5 kW at a power factor of about 0·9. The components are arranged so that they are accessible through the two rear doors of the cubicle and the internal gangway, thus facilitating servicing and maintenance.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Screw Lamp Caps and Lampholders.—A British Standard Specification covering the dimensions of Edison-type screw lamp caps and lampholders was first published in December, 1919, and was revised in 1934. The specification has now been revised for the second time, and is issued as B.S. No. 98-1947. In this latest revision, dimensions and tolerances are given for five sizes of caps, sockets and gauges, namely, E.40/45 (goliath); E. 27/25 (medium); E. 14/23 (small); E. 10/13 (miniature); and E. 5/8 (lilliput). Particulars of the central contact area, types of terminals, clearances, and limiting voltages and wattages for the various sizes, are also given. The alternative medium-size cap, E. 27/35, included in the 1934 revision of the specification, is now no longer recognised as a standard, and the lilliput (E. 5/8) size has been included in the specification for the first time. The illustrations and dimensions of the entire range of sizes have been brought into line with those agreed upon internationally by the International Electrotechnical Commission, and the end of the threaded portion of the cap is defined in a more precise manner than hitherto. [Price 2*s.* 6*d.*, postage included.]

Zinc.—The British Standards Institution have now re-issued, under one cover, three specifications which have been out of print for some time, namely, B.S. No. 220, covering fine zinc, Grades A and B; B.S. No. 221, which deals with special zinc; and B.S. No. 222, concerning foundry zinc. The specifications have been reviewed and it has been decided to make a slight modification to the chemical composition of Grade A, fine zinc, and to discontinue the use of the term "spelter." Otherwise, the requirements remain unchanged. The three specifications give the chemical compositions of all the grades of zinc covered and deal also with the method of preparing samples for analysis. It may be recalled that a specification for high-purity zinc is published separately as B.S. 1003, but under the same cover as B.S. 1004, which deals with zinc alloys for die-casting. [Price of the publication containing B.S. Nos. 220-222 (1947) and of that containing B.S. 1003-1004 (1942), 2*s.*; postage included in each case.]

TYRE PRODUCTION IN GREAT BRITAIN.—According to Board of Trade figures, the new tyres produced in this country during June, 1947, totalled 438,940 for motor cars, 176,722 for commercial vehicles, 29,611 for tractors and dumpers, 44,107 for motor cycles, 1,152,136 for bicycles, and 65,259 for other vehicles. These figures show a marked increase over those for recent months.

BOOKS RECEIVED.

Belfast Harbour Commissioners. Centenary, 1847 to 1947. The General Manager, Belfast Harbour Commissioners, Harbour Office, Belfast.

Workshop Practice: A Practical Text Book. By F. JOHNSTONE TAYLOR. Ninth Impression. The Technical Press Limited, "Piccancot," Gloucester-road, Kingston Hill, Surrey. [Price 18*s.* net.]

Year Book of the Heating and Ventilating Industry. Technitrade Journals Limited, 8, Southampton-row, London, W.C.1. [Price 5*s.* net.]

The Institution of Mining Engineers. Associate Membership Examinations. Question Papers for the First, Second and Final Examinations, July, 1947. The Secretary, The Institution of Mining Engineers, Salisbury House, Finsbury-circus, London, E.C.2. [Price 2*s.* each, post free.]

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 24. *Mechanical Decking of Cages.* By ARNOLD MULLER. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* net.]

L.M.S.R. Modernised Traffic Control Organisation. The Railway Gazette Offices, 33, Tothill-street, Westminster, London, S.W.1. [Price 2*s.*]

The British Non-Ferrous Metals Directory, 1947. Metal Information Bureau, Limited, Princes House, 39, Jermyn-street, London, S.W.1. [Price 5*s.*, post free.]

Factory Costing and Organisation. A Text-Book for Students and a Reference Book for Those Concerned with Workshop Production. By H. H. EMSLEY in collaboration with J. LOXHAM. Third edition. Constable and Company, Limited, 10, Orange-street, London, W.C.2. [Price 7*s.* 6*d.* net.]

The Engineer in Society. By JOHN MILLS. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 2·50 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 14*s.* net.]

Great Loco Story. Churchward's Work on the G.W.R. By R. L. GREY. Quadrant Publications, 390, Wakefield-road, Huddersfield. [Price 2*s.* 7*d.*, post free.]

The First Railway in Norfolk. By GEORGE DOW. Second and enlarged edition. The Advertising Manager, 26, Pancras-road, London, N.W.1. [Price 1*s.* 6*d.*]

The Other Battle. Being a History of the Birmingham Small Arms Company, Limited, with Special Reference to the War Achievements of B.S.A. Guns Limited, B.S.A. Cycles Limited, and the Other Subsidiary Companies Directly Administered from the Head Office of the Parent Company at Small Heath, Birmingham. By DONOVAN M. WARD. The Birmingham Small Arms Company, Limited, Small Heath Works, Birmingham.

Ministry of Fuel and Power. Committee on the Efficient Use of Fuel. Fuel Efficiency Bulletin No. 49. *The Handling and Storage of Coal.* Ministry of Fuel and Power, Queen Anne's Chambers, Dean Farrar-street, Westminster, London, S.W.1. [Free.]

Report of the Astronomer Royal to the Board of Visitors of the Royal Observatory, Greenwich, from May 1, 1946, to April 30, 1947. The Astronomer Royal, Royal Observatory, Greenwich, London, S.E.10.

American Society for Testing Materials. Index to A.S.T.M. Standards, as at December, 1946. Including List of Titles, in Numerical Sequence, of A.S.T.M. Serial Designations. The Secretary, American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pa., U.S.A. [Free.]

Van Nostrand's Scientific Encyclopedia. Second edition. D. van Nostrand Company, Incorporated, 250, Fourth-avenue, New York 3, U.S.A. [Price 12 dols.] Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 65*s.* net.]

Methods of Measuring Temperature. By DR. EZER GRIFFITHS, F.R.S. Third edition, revised. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 20*s.* net.]

Industrial Research, 1947. Advisory Editor: DR. PERCY DUNSHEATH. Todd Reference Books Limited, 49, Park-lane, London, W.1, and Geo. G. Harrap and Company, Limited, 182, High Holborn, London, W.C.1. [Price 25*s.* net.]

COLD-ROLLED SECTIONS ASSOCIATION.—An Export Section has now been formed within the Cold-Rolled Sections Association to assist firms to establish and expand their export trade. Its activities will cover cold-rolled sections in mild, alloy and stainless steels and in non-ferrous metals. Shapes may also be built-up using more than one metal strip and may incorporate wood or plastic material. Inquiries should be addressed to the secretaries of the Association, Messrs. Frank Impey and Company, Lombard House, 144, Great Charles-street, Birmingham. (Telephone: Central 2073/4/5.)

PERSONAL.

MR. P. GOOD, C.B.E., has been elected President of the Institution of Electrical Engineers. MR. R. H. RAWLL has been elected chairman of the Installations Section Committee; MR. D. C. GALL, chairman of the Measurements Section Committee; MR. C. E. STRONG, O.B.E., B.A.I., chairman of the Radio Section Committee; and PROFESSOR W. J. JOHN, B.Sc. (Eng.), chairman of the Transmission Section Committee. All the above have been elected to fill vacancies which will occur on September 30.

The Minister of Transport has appointed the following to be full-time members of the British Transport Commission. SIR CYRIL HURCOMB, secretary to the Ministry of Transport; LORD ASHFIELD, chairman of the London Passenger Transport Board; MR. JOHN BENSTEAD, general secretary, National Union of Railwaymen; LORD RUSHOLME, general secretary, Co-operative Union, Limited; and SIR WILLIAM VALENTINE WOOD, President of the London Midland and Scottish Railway. Sir Cyril Hurcomb is to be the chairman of the Commission, and it is hoped soon to announce the appointment of a part-time member drawn from Scotland.

MR. F. C. BARROW, assistant chief railway-service representative (shipping), London Midland and Scottish Railway, Leadenhall-street, London, E.C.3, has been appointed chief railway-service representative (shipping) and Associated Humber Lines representative, London. MR. G. E. CASSIDY and MR. R. G. LAYBOURNE have been promoted assistant chief railway-service representatives.

Arising out of the appointment of MR. A. H. M. JACOB as an executive director of Messrs. W. T. Henley's Telegraph Works Company, Limited, 51 and 53, Hatton-garden London, E.C.1, he has resigned the position of secretary. MR. R. F. GYNGELL, who has been assistant secretary of the company for a number of years, has been appointed secretary as from August 1.

DR. HUGH O'NEILL, M.Met., who has been chief metallurgist at the London Midland and Scottish Railway Research Laboratories, Derby, since 1935, is succeeding DR. C. A. EDWARDS, F.R.S., as Professor of Metallurgy in the University College of Swansea. Dr. Edwards is retiring at the end of the present session and Dr. O'Neill will take up his new duties on September 1.

The Colonial Office have appointed MR. J. H. COMMON, B.Sc., A.M.I.C.E., A.M.I.Mech.E., an executive engineer in Fiji; MR. V. DONOGHUE, A.M.I.E.E., an executive engineer (electrical and mechanical) in the Public Works Department, Jamaica; MR. J. F. NICHOLAS, B.Eng. (Sheffield), an executive engineer in the Public Works Department, Sierra Leone; MR. J. B. STAUNTON, an executive engineer in the Public Works Department, Gold Coast; and MR. P. A. THOMPSON, a mechanical engineer in Nigeria.

MR. HENRY BURNS has left the head office of MESSRS. THOS. W. WARD, LIMITED, Albion Works, Sheffield, to open and take charge of a new office in New Zealand. He will be responsible for the representation of the firm's interests and those of certain of their associated and subsidiary companies in New Zealand. The address of the office will be announced in due course.

Owing to the expansion of business in the London and South Eastern area, MESSRS. SPENCER AND HALSTEAD LIMITED, Ossett, Yorkshire, have transferred their London office to larger premises at 8, West-street, Epsom, Surrey (Telephone: Epsom 2201). The office is in charge of the area manager, MR. H. H. BRIDGE.

PHILIPS LAMPS LIMITED, Century House, Shaftesbury-avenue, London, W.C.2, announce that, on September 1, the name of the company will be changed to PHILIPS ELECTRICAL LIMITED. The old name, it is felt, is no longer suitable, as the firm's activities cover a wide range of electrical development and manufacture.

ALUMINIUM UNION LIMITED announce their return from Grosvenor House, Park-lane, to The Adelphi, Strand, London, W.C.2, as from August 18. (Telephone: TEMple Bar 3535.)

MESSRS. VICKERS-ARMSTRONGS LIMITED have acquired the sole manufacturing and selling rights, in this and other countries, of the Scott high-speed rotary newspaper printing press and other presses, from MESSRS. WALTER SCOTT AND COMPANY, INCORPORATED, Plainfield, New Jersey, U.S.A. The machines will be known as the Scott-Vickers presses, and will be made at Messrs. Vickers-Armstrongs works, Newcastle-upon-Tyne.

Owing to their own heavy development programme, MESSRS. A. C. WICKMAN LIMITED, Coventry, have relinquished their agreement with the KEARNEY AND TRECKER CORPORATION, Milwaukee, Wisconsin, U.S.A., covering the manufacture and sale of Milwaukee machines in this country. The manufacturing rights have been obtained, as from September 15, by MESSRS. C.V.A. JIGS, MOULDS AND TOOLS, LIMITED, Hove, Sussex, while the sole selling agents are to be MESSRS. E. H. JONES (MACHINE TOOLS) LIMITED, Edgware-road, The Hyde, London, N.W.9.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Production has now reached its pre-holiday peak, which means that Scotland is producing about 38,000 tons of ingots and castings weekly, this being the tonnage that the present plant can turn out effectively. Plate mills were slower in getting under way after the holidays than was expected, due to overhauls and a breakdown, and the men have agreed to work extra shifts to make up the lost tonnage and prevent any hold-up of shipbuilding and other activities dependent upon plates. Raw materials for steelmaking are forthcoming regularly and fuel supplies are being maintained to meet all demands of the works for smelting and rolling. It is expected that the special priority arranged to keep up steelmaking activity will result in maximum weekly outputs for some months to come. Semies, however, are still in very short supply, so that sheet and other light products are being allocated sparingly. Pig-iron and scrap supplies remain normal

Scottish Coal.—Rather lower outputs have been general since the holidays, but seasonal factors have reduced demands from domestic users, and no serious problem has arisen in meeting current needs. Broadly, the output is about 35,000 to 40,000 tons lower than it was when the six-day week was abandoned at the beginning of May. It is hoped that this deficit will be wiped out when the men commence to work (as they propose to do) each alternate Saturday, beginning in September, but there will be no real gain, as far as can be anticipated at present, on the figures achieved on the old six-day week. At the moment there appears to be some unrest in the Lanarkshire coalfield and the complete stoppage which broke out at Southfield Colliery, Shotts, last week, confirmed this. Amid all the talk of expanding coal output to avert a serious restriction of economic activity during the winter, the fact is that in many parts of the coalfield in Scotland outputs are low when they should be high. The initial efforts made to put in a fuller day's work when the Saturday holiday was conceded have already slackened off considerably, and this is borne out by the figures of output available. On the other hand, the Scottish miners are understood to be quite willing to work 11 days each fortnight, but this plan could have been in operation three years ago if the owners and the men's leaders had introduced the scheme when it was put up to them. Taking all the measures together, there is no prospect of raising sufficient coal to start exports again. The Prime Minister's suggestion to work an additional half hour daily is an impracticable suggestion with the pits in the condition of under-development they are in to-day. There is not room to engage the men on a full eight-hour shift; and this takes no account of the additional burden on winding and transport facilities. A six or seven-day week is the only solution, and full shifts to be worked consistently. Thereby the coal shortage would be overcome in a few months. As matters stand, there is little hope of avoiding a shortage at home, and none of restarting the export drive in coal.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Pressure brought to bear upon the Ministry of Fuel and Power has resulted in a decision to deliver forthwith to coke-oven plants the full allocation of coal instead of nine-tenths. This is making the supply of coke to blast-furnaces more plentiful, and also making available more coke-oven gas to provide additional supplies for steel-melting and heat-treatment furnaces, as well as other branches of industry. Steel plants dependent upon gas have had to restrict their operations over many months; now it is expected that steel production will increase again. More labour, both skilled and unskilled, is still needed in steelworks, and the arrival of materials and dispatch of finished products needs acceleration from the low rate at week-ends when works are closed under the shorter working-week arrangement. There was a satisfactory return to duty after the annual holidays, and production is now satisfactory. Active steps continue to be taken to improve deliveries of mining machinery and equipment. Pressure also is exerted to increase deliveries of railway materials for the building and repair of locomotives, carriages and wagons. The demand for wire rods is strong and there is a continuous call for wire ropes. Firms engaged in the manufacture of agricultural-machine parts and edge tools are booking a great deal of business for next season's delivery.

South Yorkshire Coal Trade.—There were many absentees from South Yorkshire collieries after the Bank Holiday break, but, generally, the attendance was better than at other Bank Holiday periods. Accumulations for delivery are now being worked off and it has been possible to make some small additions to winter reserves. Locomotive hards have been in strong request, and the call for washed and graded steams is in excess of the supply. Gas and coking coal are moving more freely, and the make of coke is reaching the maximum. House coal is relatively quiet. Coalite is in strong demand.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Every effort is being made to cope with the overwhelming demand for iron and steel, but any material expansion in output is still difficult. The fuel situation still occasions uneasiness, but changing conditions encourage the hope of an early improvement in supplies. The provision of more coal and coke would permit an expansion in the manufacture of commodities of which very large quantities are urgently needed for home purposes and for shipment overseas. Satisfactory parcels of native ironstone and high-grade foreign ore continues to reach the consuming plants, but there is still a scarcity of pig iron. Consumers are not allowed to purchase for stock, and exports are prohibited, while delivery licences for home purposes are granted for only two months ahead. All applications for licences are carefully examined to ensure the most advantageous use of supplies.

Foundry and Basic Iron.—The inadequate supplies of high-phosphorus pig iron are still hampering operations at the plants turning out light castings and there is little hope of an improvement in the position, as efforts to increase blast-furnace outputs are concentrated on basic quality iron to deal with the heavy requirements of the steelworks.

Hematite, Low-Phosphorus and Refined Iron.—The moderate make of East Coast hematite is passing steadily into use and the demand for low- and medium-phosphorus grades of iron barely meets current needs notwithstanding the liberal use of cast-iron scrap. Refined-iron manufacturers are finding a ready sale for thin products.

Manufactured Iron and Steel.—Semi-finished iron producers have a great deal of work in hand and branches of the industry engaged in dealing with the demand for finished-iron commodities have substantial contracts to execute. Semi-finished steel is still wanted in large quantities for the re-rolling mills; prime billets and sheet bars are in the greatest demand. More steel is needed for the expansion of many branches of the Tees-side staple industries. Another rise in railway rates in October next will hit the steel industry severely as nearly six tons of material have to be transported for every ton of steel produced; in addition, steel quotations cover the cost of delivery to the consuming works. Producers of steel plates, sheets, sections and rails have commitments that will keep their plants fully occupied for a considerable time.

Scrap.—Large quantities of iron and steel scrap have been supplied and there are still many inquiries, particularly for machinery metal and heavy cast-iron in large pieces and furnace sizes.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—South Wales miners are to consider working overtime in order to provide the coal so urgently needed by the country. The matter is to be discussed shortly by a meeting of the South Wales area executive council of the National Union of Mineworkers, who will make their recommendations to the lodges. Meanwhile, the steam-coal market has been extremely short of all grades of coal. The stoppage of the mines for two days in Bank Holiday week, following a month during which various parts of the coalfield were stopped for periods of a week at a time for the staggered holidays, has meant a further diminution of supplies, which were already inadequate to satisfy all requirements. Deliveries to a number of important users have fallen into arrears due to the stoppages, and with the usual autumnal expansion in demand now in sight, it will be difficult, if not impossible, for the losses to be made good. All grades of coal have been in active request, but owing to the scarcity of supplies for early delivery, sellers have had to scrutinise all new business very closely and have been able only to accept orders in respect of most pressing requirements. No export business has been possible. Indeed, very few shipments have been made to foreign countries since the imposition of the ban last winter, and there is as yet no indication of shippers being able to resume general operations. In spite of the apparent hopelessness of the position, several foreign buyers have maintained a steady interest. The only coals being sent abroad have been a limited number of cargoes for delivery to consumers in Eire. Bunkers have been in steady request and patent fuel and cokes were scarce.

IRON ORE IN THE UNITED STATES.—The production of iron ore in the United States in May, 1947, was the largest of any month since August, 1945. Output figures issued by the U.S. Bureau of Mines show that 10,981,254 gross tons were mined in May of this year, compared with 6,574,653 tons in April and 4,578,309 tons in May, 1946. About nine-tenths of the total for May, 1947, came from the Lake Superior district.

CONTRACTS.

MESSRS. C. A. HORTON LIMITED, Brierley Hill, Staffordshire, have received the contract for the reconstruction by the London Midland and Scottish Railway of the bridges carrying Navigation-street and Hill-street over the railway near New Street Station, Birmingham. The new Navigation-street bridge will be a 507-ton steel structure having a 132-ft. span and furnished with a reinforced-concrete slab deck. The new Hill-street bridge, which will also have a concrete slab deck, will have a span of 146 ft., and the steelwork will weigh 393 tons. The subcontractors for the steelwork are MESSRS. HORSELEY BRIDGE AND THOMAS PIGGOTT, LIMITED, Tipton, Staffordshire.

Another bridge contract which has been placed by the London Midland and Scottish Railway is for the reconstruction of the railway bridge carrying the Leeds-Carlisle main line over Eastburn Beck, a tributary of the River Aire, at Kildwick, Yorkshire. The scheme provides for the replacement of the existing bridge, the centre pier of which was damaged by floods, by an all-steel span 75 ft. in length. This new span is one of a number which the railway companies kept in hand, during the war, for the emergency repair of bomb damage. The contractors for the work are MESSRS. CAFFIN AND COMPANY, LIMITED, 25, Craven-street, London, W.C.2.

LAUNCHES AND TRIAL TRIPS.

M.S. "SEAMEW."—Twin-screw cargo vessel built by Messrs. S. P. Austin and Son, Limited, Wear Dock Yard, Sunderland, to the order of the General Steam Navigation Company, Limited, London. Main dimensions: 245 ft. by 40 ft. by 15 ft. 3 in. to upper deck; deadweight capacity, 1,400 tons. Two 800-brake horse-power five-cylinder Diesel engines supplied by British Polar Engines, Limited, Glasgow, to give a service speed of 13 knots, installed by the North Eastern Marine Engineering Company (1938), Limited, Sunderland. Trial trip, August 6.

M.S. "HURUNUI."—Twin-screw general and refrigerated cargo vessel, built and engined by Messrs. Vickers-Armstrongs Limited, Walker-on-Tyne, for the New Zealand Shipping Company, Limited, London. Main dimensions: 530 ft. by 70 ft. by 39 ft. to main deck; deadweight capacity, about 14,000 tons on a summer draught of 32 ft. 6 in. Two sets of Vickers-Doxford five-cylinder opposed-piston oil engines of 12,800 total brake horse-power, to give a service speed of 17 knots. Launch, August 14.

R.N.V.R. TRAINING ARRANGEMENTS.—The Admiralty announce that officers and men of the permanent Royal Naval Volunteer Reserve are now being appointed and drafted to H.M. ships and establishments for periods of Naval training. Details of the arrangements to be made have been promulgated to the Fleet in an Admiralty Order. Many of the officers and men of the permanent R.N.V.R. have now been demobilised for two years or more, and it is essential for them to retain the efficiency which they acquired in war-time. In consequence, their periods of training will be concentrated on refresher courses, and instruction in new gear which has been introduced since the end of the war. Every effort will be made to enable them to achieve further advancement in their rank or rating. To ensure that the Admiralty may be kept informed of the standards reached, a detailed report will be rendered on the progress made and efficiency achieved by every officer and man.

COWAL HYDRO-ELECTRIC SCHEME, SCOTLAND.—The North of Scotland Hydro-Electric Board have placed the main contracts of the Cowal Constructional Scheme. This project is designed to supply the electricity demands of consumers in the Cowal district of Argyllshire and the Islands of Bute and Cumbrae. The power station, situated on the shores of Loch Striven, will have a capacity of 6,000 kW, producing annually 14 million kWh. Messrs. Crowley Russell and Company, Limited, Glasgow, have been given the contract for the major part of the civil-engineering work covering the construction of the Glen Tarsan and Glen Lean Dams, the main tunnel, aqueducts and road diversion. The Harland Engineering Company, Limited, Alloa, are to supply and erect the water turbines and electric generators of the Loch Striven generating station. This plant will consist of two 3,000-kW alternators, direct coupled to Harland "Morgan-Smith" Francis-type water turbines of 4,250 h.p. The normal speed of the turbines will be 600 r.p.m. They will operate at a gross head of 400 ft. The Glen Tarsan Dam will have an overall length of 1,046 ft. The Glen Tarsan tunnel, which will be over 4,000 ft. long, with an equivalent diameter of 6 ft. 7 in., will be driven from one face. At the lower end of the tunnel there will be a surge shaft 120 ft. deep and 15 ft. in diameter. Corrochaive aqueduct, the main aqueduct of the scheme, will be over 12,000 ft. in length. It will divert water from the Corrochaive Burn to the reservoir.

SEMI-PERMANENT BRIDGES OVER THE RHINE AT MAINZ.

(*For Description, see page* 145.)

FIG. 12. EARLY STAGE IN ERECTION OF RIVER SPANS OF RAILWAY BRIDGE.

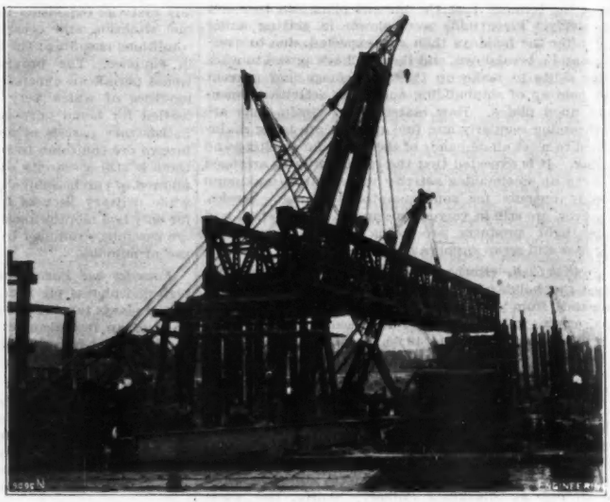

FIG. 13. PLACING ROTH WAGNER TRUSS OF RAILWAY BRIDGE.

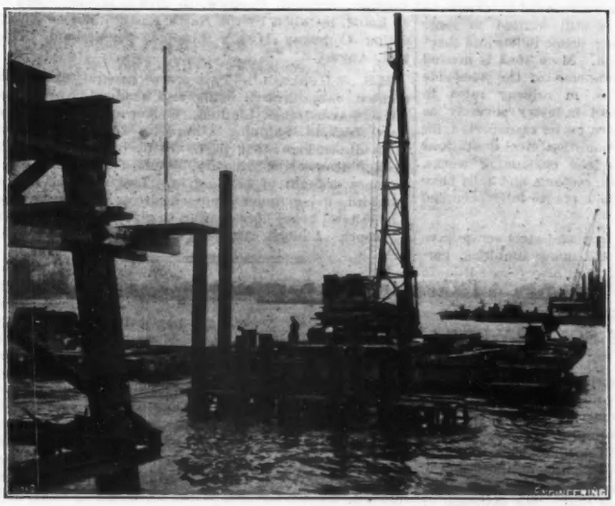

FIG. 14. PILE DRIVING FOR PIERS OF ROAD BRIDGE.

FIG. 15. DECK OF ROAD BRIDGE UNDER CONSTRUCTION.

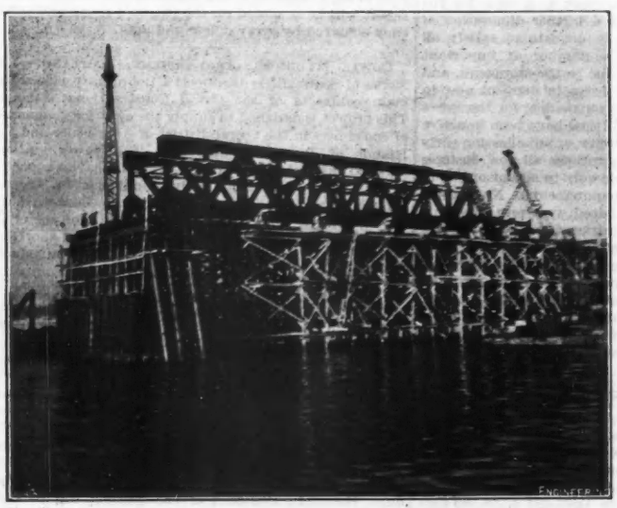

FIG. 16. ROTH WAGNER TRUSS OF ROAD BRIDGE ERECTED ON FALSEWORK.

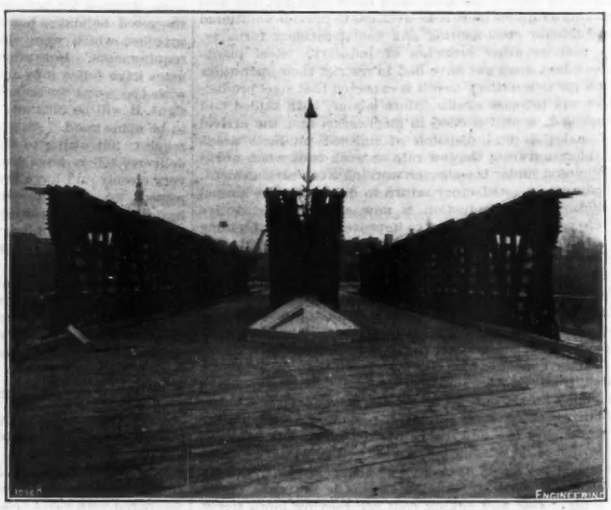

FIG. 17. DECK OF COMPLETED ROTH WAGNER TRUSSES OF ROAD BRIDGE.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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SUBSCRIPTIONS.

"ENGINEERING" may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months (or for six or three months, *pro rata*), payable in advance :—

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For Canada	£4 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates :—5 per cent. for six ; 12½ per cent. for thirteen ; 25 per cent. for twenty-six ; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, AUGUST 15, 1947.

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CO-OPERATIVE INDUSTRIAL RESEARCH.

THE dearth of scientific manpower in this country, relative to the needs of the moment and of the immediate future, has been stated so ably and so often during the past two years as hardly to admit of useful enlargement. If there is one aspect of the subject which will bear repeated emphasis, it is, perhaps, the repercussions of rapidly applied scientific discovery upon the efficiency and output of established industries, upon the founding and expansion of new industries, and hence upon the increased production of goods for home consumption and export over a period during which the critical financial situation of the country is everybody's business. This is the facet of industrial research which reflects much of the official attention now bestowed upon it, and which appeared most prominently in the message sent by the Prime Minister to the President of the Federation of British Industries at the outset of the Conference on Industry and Research, held in London in the spring of 1946. In the course of that conference, the President of the Federation and the Lord President of the Council were both outspoken to the same general effect, directing attention, on the one hand, to the devastation and accrued maintenance consequent upon six years of sustained war effort, and, on the other, pointing to the vital necessity of rapidly converting the results of scientific research into production in order to increase the volume of real exports to an extent commensurate with their value in terms of world currency, without which the relative industrial status of the nation and the life standards of its people must inevitably decline.

The textual report of the transactions at that Conference*, which has been published recently, makes it abundantly clear that the main body of the delegates, as well as the distinguished authors of the papers under discussion, were not only fully aware of the national character of the problem and of its urgency, but were able to make a number of constructive suggestions towards its solution. To accept at the outset the realistic view that, on account of even prior national commitments, the shortage of men, equipment and accommodation cannot be made good for several years is to resolve the problem into one of utilising all existing research resources to the utmost advantage. Here, obviously, is a fruitful field for discussion, and the main conclusions reached at the Conference merit serious consideration, especially by industrialists without intimate experience of applied science.

Among the first facts to be appreciated are the widespread effects of scientific discoveries, often in unsuspected directions ; and the ultimate dependence, both of fundamental discoveries and their subsequent applications in human affairs, upon men and women with original ideas. Moreover, the history of industry is full of examples of discoveries made with no thought of how they could be used, and of prosperous industries being founded on completely new scientific discoveries no less than upon the exploitation of old ones. It follows, therefore, that opportunity must be provided for a certain amount of blind research to be carried out, however pressing the demand for more visibly rewarding, if less inspired, work. With rare, yet sometimes notable, exceptions, the intellectual atmosphere of a university is most conducive to this class of research. Industry as a whole has thus an obligation to support the universities on these grounds, as well as for the reasons that an important proportion of its best technicians are recruited from universities, and that an active research school is rightly regarded as an excellent background for undergraduate training.

It is pre-eminently to the universities, too, that industry must look for attention to the cultural aspects and accompaniments of scientific education, which contribute both to administrative ability and to appreciation of good taste in design and high standards of quality. Foreign buyers of British exports can afford to be discriminating in a keenly competitive world market. There is scope for research, therefore, in ensuring not only that goods and materials are manufactured so as to be intrinsically reliable, but also that less essential features, like appearance, finish, details of shape, and method of packing, shall enhance their value and attractiveness. The very determination of the optimum extent to which such refinement is worth pursuing in relation to other costs is a worthwhile subject for scientific investigation. This is only one of many avenues that warrant thorough exploration in the general search for improved methods of converting the results of research into profitable production. Some of the others, especially such as lead to modifications of processes or plant, entailing capital expenditure, or to revised methods of production, entailing the conversion of managements and men to novel ideas, call for more than merely technical knowledge on the part of all concerned.

Herein is exemplified the principle of co-operation which runs through the whole fabric of scientific research and is of outstanding importance in the effective use of limited resources. Co-operation was the keynote of the F.B.I. Conference ; indeed the very fact that it was held indicates a need for mutual consultation and enlightenment between two of the essential agents of industrial progress, and a seeking after identity of purpose in science and management. Among the first requisites of co-operative effort on so broad a front is evidently unity within each of the allied forces, in which respect science is perhaps more advanced than industry. The belief that science is one and indivisible commands widespread acceptance, not least among its most distinguished exponents, and no less a figure than Sir Edward Appleton, in his address to the Conference, strenuously opposed the view that there are superior and inferior forms of scientific activity, according to the type of establishment in which it is carried out. It is possible to infer from this encouraging statement the belief that the technical firm which is too small to be able

* *Industry and Research.* Two-day Conference arranged by the Federation of British Industries, March 27 and 28, 1946. Published by Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 10*s.* 6*d.* net.]

to support a research laboratory should at least have on its staff one member with the qualifications and the time to study the developments in science that are particularly applicable to his firm. Experience has demonstrated that such an interpreter performs a most useful function, so long as his firm are receptive to his suggestions and encourage him to mix in scientific society. The same sort of enlightened co-operation should also inform the undertaking which has its own laboratory, so that advantage can be taken of opportunities for research arising out of routine testing, or for the publication of original work. Above all, no occasion should be missed to help the scientist and the industrial worker to know each other's problems and to respect each other's skill in serving a common objective.

An almost invariable consequence of employing research workers in commercial firms is the realisation that problems exist which are too big to be undertaken with reasonable hope of success by the limited and otherwise pre-occupied staff of a private business. In most cases, such problems are common to an entire industry, eminently suitable for consideration by the industrial research associations which have grown up under the ægis of the Department of Scientific and Industrial Research and which represent a unique and highly successful application of the principle of co-operative research. The importance, already emphasised, of applying discovery rapidly to industrial production is a challenge to be accepted, and an added responsibility to be shouldered, by every research association in the country, as well as by every unit in the industries they represent. The range of activities and the potential services of research associations figure prominently in a recent survey* of co-operative research in industry, in which the author, Dr. D. W. Hill, exercises an acute critical faculty in contrasting the organisation of industrial research in Britain and abroad, and commenting on the ideals and practice that ought to underlie its administration here.

In the course of a closely reasoned argument in favour of collaboration between every type of scientific work, Dr. Hill remarks on the comprehensive view of a whole group of related industries which is afforded to a research association, and the unique service it is able to fulfil by having contacts with the universities and manufacturing concerns. This is not to imply that the research associations ought to exercise any restrictive control over the scientific knowledge made available to industry; but rather, to the contrary, that a research association should inspire scientific activity among its member firms, and encourage them individually to undertake, for themselves, research which will be the better for including a modicum of fundamental investigation. By keeping its eyes, so to speak, on the stars, yet its feet firmly planted on the ground, such a commercial undertaking is the better able to seize on new scientific knowledge appropriate to its business, and to apply it with the least possible delay.

In many respects, the co-operative principle in industrial research is more advanced in Great Britain than elsewhere, largely as the outcome of the influential example set, and of the successful pattern laid down, by the Department of Scientific and Industrial Research. Not the least advantage of the State-owned industrial research organisation, itself in constant and intimate contact with the leaders of every grade of scientific work throughout the country, is that of being able to guide and encourage research establishments in the Dominions, and to foster the practice, no less than the spirit, of co-operative progress in industrial science. The Empire Conference, held in London last year, and the maintenance of close liaison with the United States of America on scientific developments, are both indicative of the importance with which co-operation on the widest possible scale is regarded by those best qualified to judge of its merits. In short, the value of co-operative research at every level throughout industry is generally accepted as beyond dispute. What is needed now, in order to benefit the nation's economy, is an equally general determination to apply the principle at once in every possible way.

* *Co-operative Research in Industry.* By Douglas W. Hill, D.Sc. Hutchinson and Company (Publishers), Limited, 47, Princes-gate, London, S.W.7. [Price 10s. 6d. net.]

AMENITIES IN THE FOUNDRY.

Foundry work has been stated to be among the various occupations suffering from a shortage of labour, and Government speakers have suggested that inducements should be devised to recruit workpeople for this and other "unattractive" trades. These somewhat formless suggestions may possibly crystallise into something specific now that it has been announced that the Government "propose to reimpose the control over the engagement of labour, which was almost universal during the war." This statement cannot usefully be discussed until more is known about the actual intentions behind it, but the question of the "unattractive" nature of foundry work remains open for consideration. Founding is an essential industry, it is a skilled and interesting job, and the activities it involves are considerably less unattractive than, say, those which are constantly undertaken by hospital nurses. The notion that work must be "attractive" is founded to a considerable extent on the creation of "the wrong atmosphere in the period of post-war reconstruction" with which Sir John Anderson charged the Government in the course of the debate on the economic crisis in the House of Commons last week. It may be more pleasant to stand or sit by a semi-automatic lathe, paying more attention to "music while you work" than to the job in hand, than it is to devote skilled consideration to the construction of an intricate core, but it is considerably less interesting to a worker who takes his job seriously.

At the present time when there has "undoubtedly been a failure on the part of some workers to realise that shorter hours and higher wages must be matched by greater effort" and when "we must concentrate on projects which will give quick returns in additional exports or in strengthening our industrial structure," it seems desirable to utilise our present manufacturing equipment to the full and to devote any time and money available to the improvement of its mechanical efficiency rather than to expend a proportion of that effort in the provision of amenities. "Sufficient and suitable baths," "adequate supplies of warm water laid on and of clean towels, soap and nail-brushes," "a suitable changing room" and the "stanchions, beams and services (of a foundry) . . . treated in bright contrasting colours to give variety" are no doubt all very nice and may exist in some modern works, but the present task appears to be the utilisation to the full of the equipment already in existence and the postponement of some of the ingredients of an earthly paradise until a financially stable situation has been reached.

These remarks may appear to constitute but a caustic welcome to a recent report* on conditions in iron foundries. It has been drawn up, under the auspices of the Ministry of Labour and National Service, by a committee consisting of representatives of employers and trade unions, with a technical adviser nominated by the Institute of British Foundrymen and including, in addition, various inspectors of factories. The committee was set up in August, 1945, at the instigation of Sir Wilfred Garrett, at that time Chief Inspector of Factories. The main objectives which the committee had in mind were the "provision of better amenities and more comfortable and healthy conditions"; "improvement in the appearance of ironfoundries through better cleanliness and orderliness and more light and colour"; and "improvement in the atmospheric conditions by prevention or removal of dust, smoke and fumes." These three objectives are stated in the order in which they are listed in the report.

At the present industrial crisis, it might appear that the last is the most important. Improvement in atmospheric conditions may increase productive efficiency and have a favourable effect on the health of the workers. It is perhaps not the fault of the committee that welfare and amenities were given precedence. It was not asked to advise on mechanical efficiency and output; but the result is that much of the report has little relevance to present conditions. Of the 2,000 ironfoundries in Great Britain, it is admitted that in some "methods have not changed appreciably during the last 50 years," and that many "suffer from being housed in poor premises built in days when too little attention was given to working conditions." It really seems useless to recommend that foundries of this type should install baths, changing rooms and similar amenities. Apart from the fact that frequently no space would be available for such additional accommodation, the firms concerned would not be able to obtain the necessary material and labour for building and equipment, even if they could afford them. Modern foundries, frequently highly mechanised, are not in need of advice about cloakroom and similar accommodation, and in any case the provisions suggested do not differ from those already found in many modern engineering factories.

By far the most useful part of the report is that concerned with methods for reducing the amount of smoke, fumes and flying dust which pollute the atmosphere of many foundries. To a large extent, these are already suppressed in modern highly-mechanised works, but the lay-outs and equipments involved cannot be adopted by the average foundry now, nor in the proximate future. The Committee must be given credit for recognising this, and in the treatment of some of the aspects of the smoke and fume problems in the report various wise saving clauses appear, such as "other than in exceptional cases where it can be shown to be unavoidable." First place is given to the question of open fires, which are frequently used for drying purposes. It is realised that for certain purposes, such as heating lifting hooks in heavy foundries or for drying cores after they have been damaged and repaired, such fires are unavoidable, but it is recommended that fires built in ladles, braziers or fire baskets should not be brought into the foundry until they are burning brightly and should be removed immediately after the work necessitating their use has been completed. It is suggested that the industry should endeavour to develop techniques which would eliminate the use of open fires. One example of this is furnished by the provision of a ladle-drying station outside the foundry; this would render unnecessary the common practice of drying and heating ladles by building fires in the ladle bottoms or in a brazier placed inside them.

Mould drying is another example of an operation for which open coke fires are commonly used. Stoves are used to dry many types of mould, but pit moulds cannot be dealt with in this way. It is tentatively suggested that radiant heat produced by gas or electric appliances might be used for this purpose, but it is admitted that the technique of such an operation has not been worked out yet. Portable coke-fired mould driers used in conjunction with a fan or compressed-air supply are stated to have been used in some foundries for many years. They are not fitted with flues, but good combustion is obtained and it is stated that, providing good ventilation is maintained, there is little risk from offensive fumes or smoke. Although the use of open fires for drying moulds is deprecated, the report states that "it would not be practicable to suggest their total prohibition." It will have been gathered from the tone of this article that this is not considered to be the time to prohibit anything which is facilitating output. The main recommendations in connection with mould and core stoves are that there should be enough of them and that they should be maintained in good condition.

Pollution of the atmosphere by flying dust is caused by knock-out and dressing operations. In some mechanised foundries the dust created by the former operation is subjected to an exhaust draught, so that much of it is caught in side hoods or passes downwards through a floor grid. It is admitted that arrangements of this kind cannot be adopted in heavy and jobbing foundries, and it is suggested that knock-out operations should, if possible, be carried out in special rooms or in a partitioned-off space. The same recommendation is made in connection with dressing operations.

* *Report of the Joint Advisory Committee on Conditions in Ironfoundries.* London: H.M. Stationery Office. [Price 6d. net.]

NOTES.

THE NATIONAL CRISIS.

As a matter of record, it seems desirable that some reference should be made here to the Parliamentary events of the past ten days; for, while the discussions on a brief enabling Bill may not appear to concern directly a journal such as ENGINEERING, there can be no question that the events which gave rise to the "Bill to extend the purposes of the Supplies and Services (Transitional Powers) Act, 1945," and the probable developments of the immediate future, are going to affect the lives of all engaged in the engineering and allied industries. The disturbing influences will not be confined to this particular section of the community, of course; but the rest of the nation, which depends much more upon the work of engineers than most of its constituent members realise, are likely to suffer the more acutely in proportion as "these present discontents" prevent the engineers from pursuing their normal task of improving the amenities and resolving the difficulties which characterise the life of the ordinary citizen, whatever his occupation or circumstances. The matter which led to the debate on "the state of the nation" in the House of Commons on August 7 and 8 was the imminent exhaustion of the American loan, but it would be entirely wrong and misleading to regard this as the cause of the crisis. The cause lies much deeper; as has been pointed out very cogently in newspapers of practically every colour, it is the simple fact that Britain, as a nation, has been living beyond the national means, at a rate which was stated by the Prime Minister to be more than 700,000,000*l.* on the wrong side in the first six months of this year. Various proposals were put forward by Mr. Attlee to meet this deficit, but they promised a reduction of little more than a quarter of this sum. As important features of these proposals were restricted imports of petrol and timber, it seems probable that industry will suffer additional handicaps on these two accounts. Fundamentally, however, the crux of the problem is coal production. A target has been set of 200,000,000 tons per annum, but it will be a pleasant surprise if this figure is reached; at least 10,000,000 tons less seems to be more likely, and this casts grave doubt on the possibility of attaining that other target, hardly less important, of 14,000,000 tons per annum of steel. Without adequate supplies of coal and steel, the greater part of the productive industry of the country will be faced with an almost insuperable obstacle to the maintenance of even the present unsatisfactory rates of output; and insistence on a higher volume of exports, in such circumstances, must mean a rapid increase in the general difficulties of industry. As a means of solving these growing problems, the much-criticised Supplies and Services Act is a poor remedy. Its purposes are "promoting the productivity of industry" . . . fostering and directing exports . . . reducing imports . . . redressing the balance of trade and—the clause which aroused the keenest antagonism —"generally ensuring that the whole resources of the community are available for use, and are used, in a manner best calculated to serve the interests of the community"; but there is no indication at all of how these sweeping powers of coercion can be applied in the only way that will offer a real and immediate relief, namely, to increase coal production by a million tons a week. If that could be done, the crisis would be over. Until it is done, there seems little prospect of anything but a steady accumulation of difficulties to the point when the industrial machine ceases to function. and the re-imposition from October 1, of the "direction" of labour will not help matters. The real crisis is still to come.

THE ENGINEERING SECTION OF THE BRITISH ASSOCIATION AT DUNDEE.

As mentioned in our issue for June 6, 1947, on page 479, the sessions of Section G (Engineering) at the forthcoming meeting of the British Association in Dundee, will be held in the Engineering Department of University College, and will commence at 10 a.m. on Thursday, August 28, when the President of the Section, Sir William Halcrow, will deliver his address. His subject will be "Progress in Modern Engineering." At 11 a.m., Mr. N. Cochrane will present a short paper entitled "An Analysis of the Position in Soil Mechanics," and this will be followed at 11.30 a.m., by a paper by Mr. H. Ridehalgh on "The Development of Dry Docks." On Friday, August 29, at 10 a.m., Professor Jack Allen will present a paper on a "Tidal Model of the Firth of Tay," and he will be followed, at 11 a.m., by Mr. A. W. Hendry, who will give a short paper on "Welded Connections," which will occupy half an hour. The remainder of the morning will be devoted to two papers on "Roof-Top Roads." The first, by the Recorder, Wing Comdr. T. R. Cave-Browne-Cave, will deal with the general plan, and the second, by Mr. D. H. McPherson, will discuss the question of design. The meeting will be resumed on Monday, September 1, at 10 a.m., and the first paper taken will be by Mr. J. Henderson, on "Hydro-Electric Developments in Scotland." At 11 a.m., Mr. P. G. M. Dawe will deliver a short paper on "The Resistance-Capacitance Oscillator." Another short paper on "The Effects of Creep and Shrinkage in Reinforced-Concrete Structures," will be given by Mr. H. B. Seed, at 11.30 a.m. The final session of the meeting will be held on Tuesday, September 2, and the first paper taken, at 10 a.m., will be by Mr. F. S. Anderson on "The Mechanisation of Coal Mines, with Special Reference to Coal-Cutting Machinery." Two short papers, one by Mr. W. D. Garrick on "X-Ray Examination of Butt Welds," and one by Mr. J. A. Pope on "The Apparent Yield Strength of Plain-Carbon Steel," at 11 a.m. and 11.30 a.m., respectively, will complete the programme. The afternoons of each day will be devoted to visits to works, etc., and a new and commendable feature of the Dundee meeting is that the last half hour of the morning session will be devoted to a description of the afternoon visit. This should enable the members to decide beforehand which points are of the greatest interest to them and should help to economise time as well as to make the visit more instructive.

THE INSTITUTE OF TRANSPORT.

The Council of the Institute of Transport have secured new headquarters for the Institute; they have purchased the lease of 80, Portland-place, London, W.1, described as a "spacious house of great dignity," situated within five minutes walk of Oxford Circus and a few minutes of Regent's Park and Great Portland-street Underground railway stations. This house, it is pointed out, will provide excellent amenities for the pursuit of the objects of the Institute, including a common room, library, and conference rooms. Last year, Sir Frederick Handley Page, who was then the President, issued an appeal for contributions to an endowment fund to enable the Institute to secure new premises and to extend and apply more adequately the objects of the Institute. The fund has now reached 60,000*l.*, and the present President, Mr. R. Stuart Pilcher, while agreeing that this encouraging response has been an inspiration and has confirmed the Council's confidence in the cause for which the appeal was made, has issued a new appeal. He states that there is still much to be done and that if the new premises are to be used to promote the work of the Institute to the maximum possible extent, the aim should be to reach a total of 100,000*l.* Donations may be paid to the honorary secretaries of local sections if desired; otherwise, it is directed that they should be sent to Mr. Pilcher at the present offices of the Institute, 15, Savoy-street, Victoria-embankment, London, W.C.2.

MASTER OF SCIENCE DEGREE IN AGRICULTURAL ENGINEERING.

The Senate of the University of Durham have agreed to the institution of a two-year course, at King's College, Newcastle-upon-Tyne, leading to the degree of Master of Science in Agricultural Engineering. In order to be admitted to the course, candidates must hold a university bachelor's degree in agriculture or in mechanical or electrical engineering. The subjects taken will depend on whether the candidate holds a degree in agriculture or in engineering. If he is in the former category his first year's course will cover pure and applied mathematics, applied mechanics, physics, engineering drawing, engineering laboratory, a descriptive course in engineering, and agricultural economics and agricultural engineering. The two last-named subjects again figure in the student's second-year programme, in addition to soil physics, electrical engineering and workshop and works practice. Finally, the candidate will prepare a thesis on a subject dealing with farm-mechanisation. Candidates holding a bachelor's degree in mechanical or electrical engineering will take, as their first-year subjects, agriculture; agricultural botany, chemistry, economics and engineering; and animal husbandry. In their second year, they will study agricultural engineering and economics and soil physics and undertake workshop and field work, finally preparing a thesis on an agricultural-engineering subject. Applications for admission to the course should be made to the Registrar, King's College, Newcastle-upon-Tyne, 1. The course for candidates who hold a degree in agriculture will commence in September, 1947, and, for candidates who hold a degree in mechanical or electrical engineering, in October, 1947.

STANDARDISATION OF LOW-PRESSURE DISTRIBUTION VOLTAGES.

In September, 1946, the Electricity Commissioners approved "a standard system of supply" at low and medium voltages. This provided for the supply of alternating current at a frequency of 50 cycles per second and a pressure of 240 volts when two single phase circuits were used. For three-wire single phase circuits the corresponding pressures were to be 480/240 volts, while on four-wire three-phase circuits and three-wire three-phase circuits they were to be 415/240 volts and 415 volts respectively. In all cases these supplies were to be subject to the permissible variations in frequency and voltage for the time being in force under the 1937 Regulations. The Electricity Commissioners have now issued a reminder pointing out that these new voltages will become mandatory after Wednesday, October 1, 1947, for all new systems, unless some other values are specifically approved. It is further recorded that although there is no intention at present of making the new standard voltages mandatory on existing non-standard systems, agreement has been reached as to the conditions which can reasonably be applied where a change-over voluntarily takes place. These conditions place on the undertakings the liability of carrying out at their own expense such alterations and replacements as are necessary to make the consumer's existing installation suitable for use at the new voltage. Alternatively, if the consumer carries out the alterations himself he may be paid the reasonable cost of the work. These liabilities are subject to the proviso that the alterations need not be made if the existing installation is suitable for use "over a range of voltage which includes the new voltage or at a voltage not more than 10 volts above or below the new voltage." Moreover, the undertakings will not be liable for alterations that have been made after notice of the change in voltage has been given or for any claim received from the consumer after the expiration of six months from the date of the change-over. Not less than one month's and not more than six months' notice of the change must be given to the consumer, but where the change does not exceed 10 volts, this notice may be made by a newspaper advertisement. The Commissioners recognise that shortage of labour and material will probably make any extensive change unlikely at the moment. This is perhaps just as well since the shortage of plant makes it undesirable at present to raise the voltage of 230-volt systems to 240 volts owing to the consequent increase in demand. Except in the case of a change from 250 volts or 230 volts, however much preliminary investigation will be required and the Commissioners are therefore prepared to give their consent to such changes in order that the work may be put in hand as soon as circumstances permit.

GLEN SHIRE HYDRO-ELECTRIC SCHEME.—The Glen Shire Hydro-Electric Scheme, of which details were given on page 243 of our 163rd volume, (1947), has been confirmed by the Secretary of State for Scotland (the Rt. Hon. J. Westwood, M.P.).

LETTERS TO THE EDITOR.

EFFECT OF CENTRIFUGAL FORCE IN AXIAL-FLOW TURBINES.

To the Editor of Engineering.

Sir,—I am sorry that I did not notice at the time the letter of Mr. A. D. S. Carter published in Engineering of May 9, 1947, on page 388. My attention has now been drawn to it and I hasten to offer a few remarks.

Mr. Carter states that the necessity of radial equilibrium is now a well-established fact and that it has never been claimed that free-vortex flow automatically satisfies the constant specific-mass flow condition. To be quite clear I may add that for free-vortex flow a claim has been advanced (see *Proc.I.Mech.E.*, War Emergency Issue No. 12, page 496) that the centrifugal forces arising from the swirl component of the velocity are balanced by the radial pressure gradient and that this radial equilibrium is secured when the nozzle is designed so that: axial velocity = constant and swirl component × radius = constant; these two equations give heat drop decreasing towards the tip, hence pressure at nozzle outlet increasing towards the tip, this pressure gradient balancing the centrifugal forces. As I said in my original article in reference to a simple example, if this claim of radial equilibrium is correct then there is no radial acceleration and therefore no radial velocity component; obviously if there is no radial velocity component with a constant specific mass flow at nozzle inlet (axial inflow) there must be constant specific-mass flow at nozzle outlet. Particles of fluid cannot shift radially if there is no radial velocity component; therefore the claim of radial equilibrium advanced by the free vortex designers means, in effect, constant specific-mass flow at nozzle outlet and is quite clearly expressed by $\frac{\text{axial velocity}}{\text{specific volume}} = \text{constant}$ at all radii.

It is not I who superimposed the condition of constant specific-mass flow on the condition of constant axial velocity of free-vortex; the claim of radial equilibrium by free-vortex designers did that, though they did not realise it. The condition of free-vortex flow: axial velocity = constant and the consequence of the claim of radial equilibrium: $\frac{\text{axial velocity}}{\text{specific volume}} = \text{constant}$ are fulfilled when specific volume is constant and that happens with incompressible fluid; it cannot happen in gas turbines as the two equations contradict each other, as I pointed out in my article. In other words, the claim of radial pressure equilibrium, the necessity of which Mr. Carter emphasised as a well-established fact, is inconsistent with the condition of free-vortex flow: axial velocity = constant. Incidentally, the two equations defining the free vortex ((8) and (9) in my article), if they were fulfilled in an actual turbine, would result in radial pressure equilibrium, which means absence of radial velocity component, hence constant specific-mass flow, which contradicts one of the equations of free-vortex flow. The only conclusion that can be reached is that, in the known so-called free-vortex designs, free-vortex flow as defined by the two equations cannot exist. Mr. Carter now admits that "in practice, of course, bending of the stream lines (that is, radial flow) does take place." To that I have to add that my theoretical analysis agrees with this practical experience.

If Mr. Carter still thinks that my analysis is incorrect then he will have to prove that in a flow between two co-axial cylindrical surfaces, beginning with axial inflow to the nozzle, a radial flow takes place in spite of radial equilibrium; such a proof, if successful, would have a far-reaching consequence, as a fundamental law of motion is involved. There is no need to complicate the issue by secondary vortices or boundary layers, as these obviously were ignored in the description published in War Emergency Issue No. 12; that description no doubt represented the design then in vogue. It is good to hear from Mr. Carter that the true answer is likely to be secured by experiments. On that point I have to sound a warning: when flow in which supersonic velocities are involved is investigated, then an experiment with subsonic velocity, such as already carried out (see War Emergency Issue No. 12, pages 496 and 497) cannot give the correct answers.

Yours faithfully,
For and on behalf of Fraser and Chalmers Engineering Works,
B. Pochobradsky,
Chief Engineer.

Erith, Kent.
August 7, 1947.

THE NORWICH HEAT PUMP.

To the Editor of Engineering.

Sir,—In the first paragraph of Mr. J. A. Sumner's paper on "The Norwich Heat Pump," on page 116, *ante*, occurs a reference to Bell-Coleman using an engine as a refrigerator. This coupling of the names may lead to confusion. The refrigerator was entirely the work of Joseph James Coleman (1838-88), the chemist and inventor, who, on March 3, 1877, secured Patent No. 1034 for an air refrigerating machine, and installed such a machine in Young's paraffin works at Bathgate. H. and J. Bell were meat importers who asked Kelvin's advice about a refrigerating plant for a ship. He recommended Coleman to them, and so arose the Bell-Coleman Mechanical Refrigerating Company, pioneers in the frozen-meat trade. Coleman's work was such that it is a pity that his name should come second to Bell's.

Yours faithfully,
"Historicus."

August 4, 1947.

MAXIMUM THEORETICAL CO_2 IN FLUE GASES.

To the Editor of Engineering.

Sir,—The formula as given by Mr. C. Hulse in your issue of August 1, page 112, is theoretically correct, and I have to express my regret for the error in the version I gave.

Yours faithfully,
R. H. Parsons.

Upper Hazelhurst,
Ticehurst, Sussex.
August 4, 1947.

THE DESIGN OF COMPOUND CYLINDERS FOR HIGH-PRESSURE SERVICE.

To the Editor of Engineering.

Sir,—In answer to Mr. W. R. D. Manning's letter, in your issue of July 18, on page 64, the Lamé formula gives very good correlation between the bursting pressure of very thick vessels made of steel in which little deformation occurs, and the bursting strength. I am well aware that it is an elastic formula and for the general statement I also bring in the Barlow formula. This is a simple balance of forces type, and applies more nearly to vessels at the bursting pressure which deform very considerably at the natural yield of the steel.

I have considerable experience in the deliberate bursting of pressure vessels. My old company in Milwaukee, during the nearly twenty years that I was with them, tested to destruction 23 full-size pressure vessels of steel, nine of which burst at over 15,000 lb. per square inch, and one at over 20,000 lb. per square inch hydraulic pressure. Some of the vessels tested weighed as much as 80 tons.

In cases of very thick walled vessels, the ratio of thickness to diameter is not as good a criterion as is definite thickness. I am very averse from the miniature testing of pressure vessels, because of many considerations. The full-size test cuts out many assumptions, and in the long run is much more convincing. I believe that it is the least expensive method for obtaining the correct answer.

Yours faithfully,
T. McLean Jasper.

Askwith,
Near Otley,
Yorkshire.
July 24, 1947.

HAMS HALL "B" POWER STATION.

To the Editor of Engineering.

Sir—For the first time in the history of the Birmingham electricity supply undertaking, the highest thermal efficiency of any steam power station in this country has been achieved at Hams Hall "B" station. This is revealed by the latest Electricity Commissioners' returns for the year 1946. (see page 133, *ante*).

Birmingham being an inland city with no large rivers from which to obtain cold circulating water, is at a disadvantage as compared with stations using sea or river water. The cooling towers at Hams Hall are used for re-cooling the water supplied to the condensers, the temperature from which depends on atmospheric conditions and is higher than river water. The results achieved are therefore all the more creditable, as this is the first time a cooling-tower station has gained the "Blue Riband" for thermal efficiency in competition with the more favourably placed riverside plants.

Moreover the average calorific value of the coal used is very low and does not exceed 9,11½ B.Th.U. per lb., which is yet another disadvantage in securing high thermal efficiency and high availability.

Yours faithfully,
F. W. Lawton,
Chief Engineer and Manager.

City of Birmingham Electric Supply Department,
14, Dale End,
Birmingham 4.
August 7, 1947.

THE CENTENARY OF THE SWISS RAILWAYS.

By G. H. Phillips, B.Sc.

This week, in Switzerland, is being celebrated the centenary of the public opening, on August 9, 1847, of the first railway line to be laid entirely on Swiss soil. The line, about 15 miles long, connected Baden to Zürich, and was constructed by the Schweizerischer Nordbaln Gesellschaft (the Swiss Northern Railway). The original intention was to continue the line through to Basle but, because of certain difficulties, it was not found possible at the time to complete the scheme. The "Limmat" type of 4-2-0 steam locomotives, used to haul these first trains, developed about 90 horse-power and had a speed of 22 miles per hour.

Although the Federal Government had power to build railways, it was decided to support private construction and, in 1852, the Canton authorities were given permission to grant concessions. As a result, these first railways were of a somewhat local character, as many of them were intended to serve only one particular Canton. However, considerations of economy in operation induced a policy of amalgamation which resulted, eventually, in the formation of five main and several smaller groups.

The first nationalisation proposal, which was made in the Swiss newspapers about 1860, did not receive much support; but, in 1872, a law was passed which abolished the right of the Cantons to grant concessions, thus giving the Government a certain measure of control over new railway construction. Then followed several further unsuccessful proposals in favour of nationalisation; these culminated in the National Referendum of 1898, as a result of which the Schweizerische Bundesbahnen or Chemins de Fer Fédéraux (Swiss Federal Railways) came into being on January 1, 1902. On that date, two of the main line groups, the Centralbahn (Central Railway) and Nordostbahn (North Eastern Railway) were taken over, in addition to several smaller lines. The other three main groups were taken over later; the Vereinigte Schweizerbahnen (United Swiss Railways) on July 1, 1902, the Jura-Simplon Group on May 1, 1903, and the Gotthardbahn (Gotthard Railway) on May 1, 1909. Since the latter date, no further absorptions of importance have taken place, although the independent private railway systems have developed considerably until, to-day, they have

CENTENARY OF THE SWISS RAILWAYS.

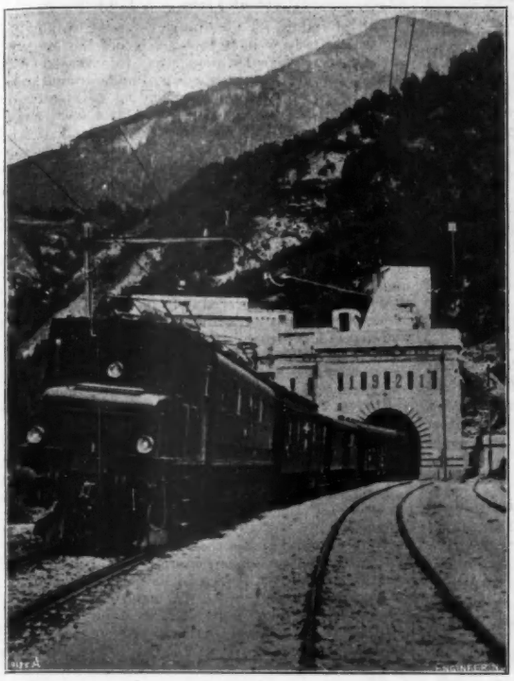


FIG. 1. LOCOMOTIVE OF AE 4/7 CLASS ON SIMPLON ROUTE.

FIG. 2. BO-BO LOCOMOTIVE USED ON LÖTSCHBERG ROUTE.

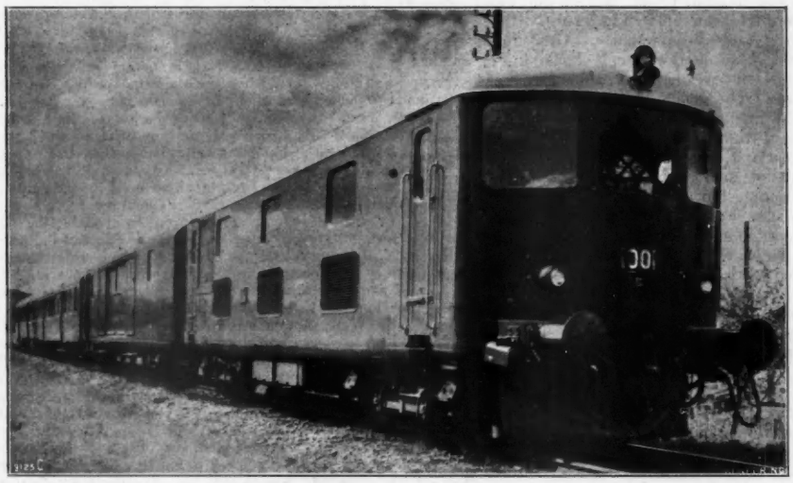


FIG. 3. DIESEL-ELECTRIC LOCOMOTIVE.

a total length approximately equal to that of the Federal Railways.

Switzerland has no coal, except for small deposits of poor quality lignite, so that almost all the coal required for railway operation had to be imported from neighbouring countries. There existed, however, enormous reserves of water power, a situation which greatly favoured railway electrification as soon as this became practicable. Even so, electrification when started was a matter of gradual development rather than a sudden drive to replace steam traction on all lines.

The first Swiss railway to be electrically operated was the standard gauge Orbe-Chavornay line, 2½ miles long, which was supplied with direct current at 500 volts from the time of its opening in 1894. In 1898, there followed the electrification of the Stansstad-Engelberg metre-gauge line, which had 14 miles of adhesion track and one mile of rack. This was the first railway of any considerable length, in Switzerland, to operate on a three-phase supply. During the following year, the Burgdorf-Thun standard-gauge railway, 25 miles long, was opened. This was the first standard-gauge railway to use three-phase current, the supply being at 750 to 800 volts and 40 cycles. After these first three, several other electrification schemes were carried out, both on standard-gauge and metre-gauge lines, direct current being generally used, at 750 to 1,000 volts.

Shortly before the opening of the Simplon Tunnel in 1906, doubts were expressed regarding the suitability of steam locomotives because of the great length of the tunnel and the consequent pollution of the atmosphere. Electric traction would have overcome this difficulty, but the proposal was not favourably received in all quarters because, at the time, electrification had been applied to only a few railways which did not carry heavy traffic. The Simplon route, however, was of international importance and traffic was expected to be very heavy, so that no risk of a possible breakdown could be accepted; and, after much discussion, it was decided to adopt electrical operation. Two locomotives under construction for the Italian State Railways and five locomotives already in service were lent by the Italians. As they were designed for three-phase current at 3,000 volts and 16 cycles, it was necessary to use this for the tunnel operation. The power was generated at the hydro-electric stations at Brig and Iselle, which had been used during the construction of the tunnel. When the tunnel was opened to traffic, it was found that the electrical operation was entirely satisfactory.

Alternating current had been introduced for railway operation because of its economy in transmission. At first, a three-phase supply was provided, but, from about 1902, several proposals were made to use single-phase current. As an experiment, the Seebach-Wettingen line was electrified in 1907 and was operated regularly until May, 1909, using single-phase current at 15 cycles and 15,000 volts; this line was the first high-voltage single-phase standard-gauge railway. The results obtained on this experimental installation served to support the arguments in favour of using current at high voltage and low frequency. Further electrification schemes were carried out before the 1914-1918 war, the scarcity of coal during that conflict giving impetus to this development. The greater part of the conversion from steam to electric traction took place during the ten years following 1918. By the end of 1945, the total length of electrified track on the Federal Railway systems was about 1,600 miles, and this is being increased, as it was decided on September 29, 1945, to electrify those sections which were still steam-operated.

The power for the Swiss Federal Railways is supplied by seven hydro-electric stations entirely owned by the railways and two others of which the railways are part owners. The railway-owned power stations generate about 50 million kWh per annum. Generation is at about 10,000-15,000 volts and 16⅔ cycles, the current being transformed to 66-kV or 132-kV for transmission to the substations, whence it is supplied to the overhead conductors at 15,000 volts; transformers on the locomotives reduce the voltage to 400 or 500 at the traction motors.

The earlier electric locomotives had motors geared to a crankshaft, from which the power was transmitted to the driving wheels by means of a side-rod mechanism. Present practice favours individual drive to each axle, but there are still quite a number of locomotives with rod-drive on the Swiss Railways. The most numerous class of electric locomotives is the Ae 4/7, which has four driven axles out of a total of seven. The type 2Do1 of this class, illustrated in Fig. 1, on page 161, has been used for hauling heavy passenger trains in various parts of the country, including the Simplon Tunnel route, which was converted in 1930 to a single-phase supply at 15,000 volts and 16⅔ cycles.

Various designs of electric locomotives have been developed to suit particular needs both on the Federal Railways and the independent railways. Of particular interest are the 8,800-h.p. twin-unit locomotives of the Ae 8/14 type, built in 1931-2 for hauling heavy trains through the Gotthard. This design was considerably modified and light alloys used where practicable, so that, in 1939, it was possible to produce a locomotive of the same type but having a total horse-power of 11,400. This was the most powerful locomotive in the world.

On the Bern-Lötschberg-Simplon Railway, operating conditions are extremely arduous, because of the weight of the trains and the severe gradients. The international expresses may weigh up to 650 tons, yet certain sections must be covered at a maximum speed of 78 m.p.h. while in other parts this load must be accelerated as rapidly as possible from signal stops. The latest type of locomotive for this line, first used in 1944, is of the Bo-Bo type, that is having two two-axle power bogies, and is shown in Fig. 2, page 161. Each axle is driven by a separate motor, so that the whole weight of the locomotive is available for the production of tractive effort. The load on each driving axle is 20 tons, which is the maximum permitted. The four traction motors deliver 4,000 horse-power, based on a one-hour rating. Although there are no pony axles, this type has very good running properties up to its maximum speed. For hauling express trains of light and medium weight, the Federal Railways introduced, in 1946, a lightweight locomotive of somewhat similar type. The weight is about 56 tons and the horse-power 2,360.

While the main-line locomotives were being developed to their present state of efficiency, the motor coaches and the locomotives of the secondary lines were also receiving attention with a view to improving their performance. This resulted in the construction of motor coaches of 1,000 h.p. for the standard-gauge Chemins de Fer Fribourgeois.

As in other countries where there was heavy competition from road-transport undertakings, Swiss railways had to develop a series of light railcars for certain sections of track, in order to regain some of the traffic which they were losing. In this connection should be mentioned the introduction of locomotives driven by internal-combustion engines. Two Diesel-mechanical railcars of 290 h.p., corresponding more or less to the "Red Arrow" electrical units, were put into service in 1935; and the latest development in this direction is a main-line Diesel-electric locomotive of 1,200 h.p., used on the Swiss Federal Railways. It is illustrated in Fig. 3, page 161. As is well known, also, the gas-turbine locomotive was supplied to the Federal Railways by Messrs. Brown, Boveri and Company during the war. This is the first of its type in the world and has an output of 2,200 h.p.; the gas-turbine unit drives a generator which supplies direct current to the traction motors.*

The steam locomotives in operation were not neglected while electrification was in progress; constant efforts were made to increase their efficiency. Compounding was adopted and the first decade of this century saw the introduction of superheating. For passenger work, the most important types were the 4-6-0 four-cylinder compounds of 1910-45, but the most powerful steam locomotives were the four-cylinder compound 2-10-0 class of 1913-17, used particularly for freight haulage on the Gotthard route. Electrification has proceeded to such an extent, however, that in 1946, only about 5 per cent. of the locomotive mileage was operated by steam.

The passenger coach most favoured has been of the centre-corridor type, with an entrance at each end, where the roof is extended over an otherwise open platform, having steps each side. Most of the early coaches had four wheels, although some with six wheels were used. Even to-day, this is the type generally used for short-distance internal traffic.

Because of the many severe gradients, it has always been a matter of extreme importance to reduce the dead weight of the trains in every possible way. This has led to a continuous reduction in the weight of coaches for a given passenger-carrying capacity. When steel coaches were first introduced, they were heavier than the contemporary wooden ones, but the greater safety and the better riding qualities obtained were considered to make the change worth while. Then, with the advent of welding, weights were again reduced until the steel coaches of the period between the two Great Wars were lighter than the equivalent wooden types of 1913. It was in 1937, however, that the greatest progress was made, when the new all-steel lightweight coaches, the chassis and body of which formed a single hollow girder, were introduced for international traffic. These departed from the usual type in having two double folding side doors, but the centre corridor was retained.

A somewhat similar construction was introduced in 1944 for high-speed internal traffic on the main lines. The restaurant cars on these trains have pantagraphs for current collection, so that cooking may continue even when no locomotive is attached. When travelling, the restaurant cars are generally supplied with current from the train circuit. When electric lighting was first installed on passenger coaches, storage batteries were utilised, but, at the beginning of the century, carriage dynamos, belt-driven from the axles, came into use. This method of drive has survived on the coaches used for short-distance internal traffic, but on the more modern types it has been replaced by a positive drive through gearing and cardan shafts. This eliminates the troubles associated with belt changing, etc., and also ensures steady operation under all weather conditions. The goods wagons are of many different types, but most of them are four-wheeled. For mineral traffic, there are high-sided wagons capable of carrying just under 20 tons, and, for special purposes, such as machinery transport, there are low-loading four-wheeled or six-wheeled types with capacities up to about 60 tons.

Apart from the use of the metre gauge on secondary routes, the Swiss railways have always adhered to the standard gauge of 4 ft. 8½ in. The permanent way is well laid and maintained, both on the main lines of the Federal Railways and on the standard-gauge and metre-gauge lines of the small independent operators. On branch lines, the flat-bottomed rails are fastened directly to the sleepers, but, where traffic is heavier, small sole-plates are inserted between the rails and sleepers. At first, wooden sleepers were employed, but metal sleepers were soon considered for certain sections on account of the heavy centrifugal forces involved in negotiating sharp curves, particularly as the weight of the trains increased. To-day, over half of the sleepers used are of steel. Although experimental lengths have been laid with concrete sleepers, the results do not seem to have been encouraging.

* See "ENGINEERING," vol. 155, page 138 (1943).

GENERATION OF ELECTRICITY.—The official returns rendered to the Electricity Commissioners show that 2,866 million kWh of electricity were generated by the authorised undertakings in Great Britain during July, 1947, compared with 2,765 million kWh during the corresponding month of 1946, an increase of 101 million kWh, or 3·7 per cent. During the first seven months of 1947 the total electricity generated was 24,522 million kWh, compared with 23,246 million kWh during the corresponding period of 1946, an increase of 1,276 million kWh, or 5·5 per cent. The total quantities sent out during July, 1947, and July, 1946, were 2,698 million kWh and 2,597 million kWh, respectively, an increase of 101 million kWh, or 3·9 per cent. During the first seven months of 1947 the total amount of electricity sent out was 23,140 million kWh, compared with 21,925 million kWh during the corresponding period of 1946, an increase of 1,215 million kWh, or 5·5 per cent.

RECENT WATER LEGISLATION.*

By SIR ROGER HETHERINGTON, C.B., M.I.C.E., and A. TITHERLEY.

(*Concluded from page* 139.)

THE procedure for obtaining powers is working, on the whole, very well. Proposals before the Ministry, involving more than 90 Orders, range from the definition of areas in which the abstraction of underground water is to be controlled, the impounding of streams or abstraction of large quantities of water from rivers, and the compulsory acquisition or amalgamation of undertakings, to relatively minor matters such as small extensions of limits of supply. In general, water undertakers are availing themselves of the procedure of the Act when new powers are needed, though a minority of undertakers have still found it necessary to proceed by Bill, in a few instances, perhaps, because they may have wished to avoid the planning control of the Act. There is nothing in the Act to prevent undertakers from exercising the right to seek powers through Private Bill procedure; but, as time goes on, undertakers doing so without special reasons might well expect severe discouragement, since it hardly seems likely that Parliament, having so recently decided that there should be a planned and defined procedure for considering new schemes for water supply, should now decide that that procedure should not be generally followed.

As may be expected with an Act so far-reaching as the Water Act, it has been found that there are minor flaws, and that points which could not easily have been foreseen when the Bill was in draft will have to be met by amending legislation when time permits. There have been representations that the Order procedure is likely to take more time than procedure by Bill; and that, with the latter procedure, work is simplified because it is known definitely, in advance, when the various interim stages must be taken, and when the decision will be made known. The Ministry have no doubt that an unopposed Order will be more expeditious than an unopposed Bill; and that the decision on an opposed Order which is submitted during the season of the year when Bills cannot be introduced will be known sooner than if the promoters waited for the Bill season. In order, however, to make sure that there are no avoidable delays, and to meet the complaint that there are no prescribed stages in the procedure, it has been agreed that, if the promoters desire, a time-table shall be prepared when it is known that a draft Order is to be submitted. The promoters will thus know, well in advance, when the stages of the procedure will be reached and when the decision may be expected.

There has been no experience yet of the effect, in terms of time and money, of opposition to an Order in Parliament; but it is improbable that the expense would be greater than for an opposed Bill, while the time required has been much reduced by the substitution of the new special Parliamentary procedure for Provisional Order procedure. In considering this question, regard must be had to the effect of the public local inquiry, and the extent to which objections are met or objectors are content with the hearing they have had during the inquiry. Some undertakers have said that the local inquiry is an undesirable feature of the Water Act procedure, that it encourages the small man to object, and that, if procedure by Bill is followed, the objections will be confined to those made by the more important interests, whose claims may often be satisfied by agreement reached during the proceedings. It is doubtful whether this is the right way of looking at the matter, or whether it is proper that the small man should be precluded, by reason of his lack of money, from being heard by putting his case in person to somebody who is able to judge the strength of it. Schemes of water supply may have serious effects on property belonging to small people, with limited financial resources, and on small consumers, and it is surely equitable that these effects should be considered before a decision is reached. It is certain that public local inquiries are of great value to the promoters as well as to the objectors. The fact that the opponents hear full reasons for the proposals, with evidence in support of the promoters' case, is sometimes sufficient in itself to convince them that their objections cannot be met; in other instances, the promoters are able, after they have heard the objections, to amend the proposals and so meet good reasons for objection; in every case, a patient and impartial hearing of the evidence will go a long way towards showing, if the objections cannot be upheld, that there are probably good reasons for the decision.

The Water Act, although it provides the powers, cannot provide the physical solution of the present problems of water supply. These are matters for the

* Paper presented on July 25, 1947, under the auspices of the Institution of Municipal Engineers, at the Public Works, Roads and Transport Congress, London. Abridged.

undertakers in the first place, with the guidance of the Ministry in so far as it is necessary for supplies to be co-ordinated with those of other authorities. This lack of co-ordination has been the worst feature of public water supplies in the past. The great majority of statutory water undertakers are providing a service which is, in many respects, a standard throughout the world; but many undertakers would be the first to agree that the service has grown piecemeal, sometimes in a wasteful fashion, and rarely in accordance with any general planning of resources and supplies. The new demands arising from the arrears of war-time, higher standards of living, and the Government's policy in relation to rural water supplies and agriculture are providing the opportunity to ensure wise planning for the future; the Water Act provides the machinery.

CHEMICAL PERSONALITIES A CENTURY AGO.*

By PROFESSOR JOHN READ, Sc.D., F.R.S.

To all who have some grasp of the enormous extent of modern chemistry, it seems astounding that three of the prime founders of the science—an Englishman, a Swede, and a Frenchman, all born in the era of "phlogiston"—were still alive at the time of the inception of the Chemical Society in 1841. I refer to Dalton, then 75, who had originated the atomic theory 34 years earlier; Berzelius, who contributed so largely to the early development of that theory; and the brilliant and versatile Gay-Lussac. These and other illustrious survivors of the dawn of scientific chemistry had long since passed their zenith; but the personalities and ideas of the men of this older generation, no less than their published discoveries, had played a great part in shaping the outlook of the chemists of the younger generation. It is a truism in the history of chemistry, as in history at large, that every period has its roots in the past, especially in the immediate past. Most of the prominent chemists of the eighteen-forties were born in the first 15 years of the Nineteenth Century; Wöhler was born in 1800, Liebig in 1803, and the first rays of the atomic theory broke over the chemical horizon in 1807.

It was at Heidelberg, in the romantic surroundings of Gmelin's laboratory, fashioned from the fragments of an ancient monastery, that Friedrich Wöhler forsook medicine for chemistry. In those days there was no public provision for instruction in practical chemistry in any country. Wöhler was fortunate to gain experience in the private laboratory of Berzelius, at Stockholm, consisting of two rooms in his dwelling-house. Here Wöhler lived and worked for the best part of a year. Justus Liebig, a native of Darmstadt, met with similar difficulties. From the Darmstadt school, where his avowed intention of adopting chemistry as a career aroused mingled incredulity and amusement, he went to an apothecary's, for want of a better way of gaining some experience of practical chemistry. Later, he studied at Bonn and Erlangen, but chose Paris, rather than Stockholm, for further work; even in France he found no public chemical laboratory, but he was fortunate, through the support of Humboldt, to gain access to the private laboratory of Gay-Lussac. Here, his successful work on fulminates led to his appointment in 1824, at the age of 21, to the chair of chemistry at Giessen, which he occupied until 1852.

Wöhler had worked on cyanates at Stockholm, Liebig on fulminates at Paris. Thus it came about that their converging lines of work brought them together in person. So began that historic life-long friendship which exerted so great an influence on the progress of chemistry a century ago. In the 'forties, we find them at the head of two famous schools of instruction and research—Liebig's at Giessen and Wöhler's at Göttingen. Their early struggles had led them to realise the imperative need of providing chemical laboratories open to students and research workers alike. During Wöhler's first 21 years at Göttingen—from 1836 to 1857—more than 8,000 students passed through his lecture-room and laboratories.

At Giessen, in Upper Hesse, Liebig had taken on the mantle of Berzelius as the dominating figure in chemistry. His teaching methods were no less important to chemistry than his classical researches. In his own words: "Actual teaching in the laboratory, of which practical assistants took charge, was only for the beginners; the progress of my special students depended on themselves. I gave the task and supervised its carrying out . . . We worked from break of day till nightfall. Dissipation and amusements were not to be had at Giessen."

Trautschold has left a pictorial record of the main working-room of the Giessen Laboratory in 1842, and among its inmates are to be seen a typical selection of the numerous chemists who passed through Liebig's hands; among others, Will, Strecker, Varrentrapp and Hofmann. The Giessen laboratory was the first to be equipped with working-benches provided with cupboards, drawers and shelves. There was no gas, of course, and the Bunsen burner was not yet invented; heat was provided by charcoal fires and spirit lamps. Hofmann pointed the contrast between the fiery and impetuous Liebig, "seizing a new thought with enthusiasm" and the calm and deliberate Wöhler, "entering upon a fresh problem after full reflection." Great as was this contrast, Liebig and Wöhler shared an eagerness of spirit and an intense love of truth. "Can we marvel," asked Hofmann, "that between two such natures, so differently ordered, and yet so complementary, there should ripen a friendship which both should reckon as the greatest gain of their lives?"

Wöhler (who outlived Liebig by nine years) went to Göttingen from the *Gewerbeschule* at Cassel, and here, in 1836, he was succeeded by Robert Wilhelm Bunsen, then 25 years old. Bunsen was a native and graduate of Göttingen, and had obtained a brief experience in Paris, Berlin and Vienna. From 1839 to 1851, he was professor of chemistry at Marburg; but he is chiefly remembered for his memorable reign of 31 years in the chair of chemistry at Heidelberg, where he succeeded Leopold Gmelin. Meanwhile, in 1852, Liebig had migrated from Giessen to Münich, where his ardour for research appeared unable to survive his emergence as a great public figure. At that time, indeed, the chemical centre of gravity passed from Giessen to Heidelberg, where Bunsen grew to his full intellectual stature. Bunsen, without doubt, was one of chemistry's greatest figures in the Nineteenth Century, and his active labours extended over a period of nearly 60 years.

Bunsen at Marburg, like Liebig at Giessen, led a very quiet life in the 'forties. He was a man of simple and abstemious habits, whose pupils regarded him with a deep affection, which constantly shines through the reminiscences of his erstwhile pupil and later colleague, Sir Henry Roscoe. "He stood fully 6 ft. high," wrote Roscoe, "his figure was well knit and powerful, his manner was one of suave dignity, while his expression was that of great kindliness and rare intelligence . . . he disliked assumption . . . hated duplicity . . . abhorred vanity and despised popularity-hunting. Entirely devoted to his students, as they were to him, he spent all day in the laboratory."

At Heidelberg, between 1852 and 1855, Bunsen worked in the converted monastery which he had inherited from Gmelin, and Roscoe has left a vivid picture of the conditions under which practical work in chemistry was conducted at Heidelberg a century ago: "The cloisters were enclosed by windows and working benches placed below them. Beneath the stone floor at our feet slept the dead monks, and on their tombstones we threw our waste precipitates. There was no gas in Heidelberg in those days, nor any town's water supply. We worked with Berzelius's spirit-lamps, made our combustions with charcoal, boiled down our wash-waters from our silicate analyses in large glass globes over charcoal fires, and went for water to the pump in the yard. Nevertheless, with all these so-called drawbacks, we were able to work easily and accurately."

In 1825, a young student of 22, named Carl Löwig, brought to Gmelin a red liquid which he had prepared by the action of chlorine on a mother-liquor from a mineral spring at his native Kreuznach; but before he was able to go home and prepare it in sufficient amount the French chemist Balard announced the discovery of bromine. In 1833, Löwig became the first professor of chemistry at the University of Zürich in Switzerland, where he remained until 1852, when he succeeded Bunsen at Breslau. He was an early worker on organic compounds of sulphur, selenium, tin, and lead.

In France, the outstanding chemical figure at that time was Dumas. Born in 1800 at Alais, near Nimes, he had been apprenticed to an apothecary upon leaving the local school. When not quite 16 years old, he showed his energy and enterprise by walking more than 200 miles to Geneva, the nearest scientific centre of any note. At Geneva, while continuing pharmaceutical work, Dumas attracted the attention of Pictet, the physicist, de Candolle, the botanist, and La Rive, the chemist. One day, he had the further good fortune of making the acquaintance of Baron Alexander von Humboldt, who had a remarkable instinct in those days for discovering and encouraging young scientists of promise. During a walk round Geneva, von Humbolt spoke to the young man of Laplace, Berthollet, Gay-Lussac, Arago, Thenard, Cuvier, and many other members of that Parisian galaxy, unsurpassed in the annals of science. "I listened with a strange delight," wrote Dumas, "a new horizon began to dawn upon me. . . . My mind was soon made up; I must go to Paris." To Paris he went; and in Paris he spent the rest of his life.

Dumas was singularly fortunate in his scientific career. Already, in his early twenties, he secured scientific recognition in Paris. From that time onwards, he was able to develop to the full his manifold gifts as chemist, teacher, writer, orator, and man of affairs in the wider world. His versatility in chemical research was accompanied by an equally remarkable general versatility. He attracted many workers whose names were to become household words in chemistry, among them Gerhardt, Laurent, Piria, and Stas. He became a brilliant expositor of chemistry. In 1842, Louis Pasteur, then a young student of 20, wrote: "I attend at the Sorbonne the lectures of M. Dumas, a celebrated chemist. . . We have to be there half an hour before the time to get a good place as you would in a theatre . . . there are always six or seven hundred people."

The revolution of 1848 ushered in Dumas's career as a politician; he became Minister of Agriculture and Commerce in 1849, and later was made a senator. After 20 years of public life, his official career came to an end with the collapse in 1870. Few distinguished chemists have time to become public figures, and it is therefore appropriate to quote an opinion which he expressed in his later days to Sir Henry Roscoe. "I have seen many phases of life," he said, "I have moved in Imperial circles, I have been Minister of State; but if I had to live my life again, I would always remain in my laboratory, for the greatest joy of my life has been to accomplish original scientific work, and, next to that, to lecture to a set of intelligent students."

At the time of Berzelius's death, in 1848, there were two young chemists who seemed destined to bring great renown to French chemistry: Laurent was then 41 and Gerhardt only 32. Fate was unkind to both; neither shared the good fortune of passing into the new age of structural chemistry, which owed so much to their own ideas and researches. Both Laurent and Gerhardt had worked under great handicaps. Writing to Gerhardt when in his early thirties, Laurent said that he could scarcely afford to drop an extra lump of sugar into his morning cup of coffee without counting the cost. Laurent had the artistic temperament and composed the words and music of a comic opera—and the mention of a musical chemist is a reminder that it was only a few years later, in 1868, that Borodin, the famous composer, became assistant professor of chemistry at the St. Petersburg school of medicine. As for Laurent, he carried out his later work in a damp and unwholesome corner of the Mint in Paris, and died of tuberculosis in 1853, at the age of 46.

Gerhardt spent some time at Giessen in his 21st year, and in 1838 made his way from Strassburg to Paris, largely on foot, with 200 francs and a testimonial from Liebig in his pocket. He became lecture assistant to Dumas, and although, in 1844, he was appointed to a chair at Montpellier, it was not until he succeeded to the chair of chemistry at Strassburg, in 1855, that he came into possession of an adequately equipped laboratory. In the next year, when barely 40 years old, this Keats of French chemistry died with the cry on his lips: "O for another 15 years in which to finish my work!"

These two personalities, of such poignant interest in French chemistry of a century ago, were closely associated in their chemical careers as well as in their ideas. Of them, Wurtz has said that "the great figure of Gerhardt will never be separated from Laurent; their work was collective, their talent complementary, their influence reciprocal." Adolphe Wurtz, like Gerhardt, came from Strassburg. In 1842, he passed under the influence of Liebig at Giessen, and later he was given a place in Dumas's laboratory. His year of destiny came in 1849, when Dumas's entry into politics led to Wurtz taking over his chief's lectures. In the same year, Wurtz succeeded in proving experimentally the existence of the alkylamines, predicted by Liebig.

In Paris, in 1848, Louis Pasteur, then aged 26, discovered optical isomerism and brought to light a new branch of chemistry permeating the whole of the organic world. In striking contrast to the youthful Pasteur, standing on the threshold of a scientific career of dazzling brilliance, there was also living in Paris one whose best-known researches were already becoming ancient chemical history. Chevreul, born in 1786, began his investigations on animal fats in 1811, and published his classical work on this subject in 1823. Surviving until his 103rd year, in 1889, he bridged the immense span in historical chemistry between the era of phlogiston and the age of the asymmetric carbon atom, synthetic indigo, and the ionic theory. Conversation with Chevreul was apt to be piquant: replying to a remark on the weather, in 1883, he remarked casually, "The severest winter I have ever experienced was that of 1793." A letter which he wrote in his hundredth year is still extant in the St. Andrews collection, and there is a picture showing him at work in his laboratory in the same year; he declared himself still a student at that time.

The history of chemistry reveals no parallel to a career of such length. The nearest approach to Chev-

* Lecture delivered in London on July 16, 1947, in connection with the centenary celebrations of the Chemical Society. Abridged.

reul's record appears to be that of the Russian chemist, Zinin, who was born in the year of Napoleon's retreat from Moscow and survived until his 99th year, in 1911. It was Zinin who, some 70 years earlier (1842), first prepared aniline from nitrobenzene by reducing it with alcoholic ammonium sulphide; in 1845, he discovered azoxybenzene and benzidine. Of him, Emil Fischer wrote: "Had Zinin done no more than change nitrobenzene into aniline, his name would still have been inscribed in golden letters in the history of chemistry."

Turning from Russia to Southern Europe, we may recall that on the roll of Dumas's band of enthusiastic students in Paris is to be found the name of Piria. A century ago, Piria stood at the head of the most flourishing school of chemistry in Italy. Soon after leaving Dumas, he became professor of chemistry at Pisa, where he applied himself to researches on salicin, populin, asparagine, and naphthalene derivatives. To Piria at Pisa came, in 1845, from Palermo, a young man of 19 named Cannizzaro. This celebrated Italian chemist began his chemical career as lecture assistant to Piria; but at that time Italy was in a troubled state, and in 1847 Cannizzaro forsook the lecture bench to join the Sicilian revolutionaries and became an artillery officer in Messina. Following the collapse of the rising, he escaped from Palermo to Marseilles and was sentenced to death—fortunately for chemistry, *in absentia*. Returning to Italy in 1851, he began work on benzoic acid and aromatic aldehydes, still under the influence of Piria; it was in 1853 that he discovered the celebrated reaction associated with his name, and in 1858 that he published his famous exposition of methods for determining atomic weights and molecular formulæ.

Coming now to British chemists of this period, we find that Liebig, somewhat earlier, had dismissed them summarily in a letter to Berzelius, in 1837. "England is not the land of science," he wrote, "It can show only a widespread dilettantism; the chemists are ashamed to call themselves chemists, because the despised apothecaries have run off with the name." He had a good word only for two British chemists, both of them Scotsmen: Graham, whom he called a first-rate fellow, and Gregory. At the opening of the 'forties, Faraday's chemical researches lay well behind him, and Graham had not yet attained his full stature. At Oxford, the versatile Charles Daubeny, M.D., F.R.S., a scholar and gentleman trained in the old humanities, held the three chairs of chemistry, botany, and rural economy. "A chemist among botanists and a botanist among chemists," he wrote on such diverse subjects as volcanoes, manures, the atomic theory, and the sexuality of plants.

At Cambridge, the Rev. James Cumming, F.R.S., kindly, polished and unostentatious, busied himself with pioneer work on electromagnetism and thermo-electricity. Like Daubeny, he did not stand out as a chemist, but it has been said of him that "had he been more ambitious and of less uncertain health, his clearness and grasp and his great aptitude for research might have carried him into the front rank of discoverers." According to Cumming's pupil and successor, Liveing, towards the end of the 'forties chemical research at Cambridge was impossible "unless the man found his own laboratory and apparatus." Liveing himself started the first laboratory for students, at his own expense, in 1852, renting a cottage in Cambridge for the purpose. Incidentally, Cumming and Liveing between them had occupied the Cambridge chair for 93 years when Pope succeeded to it in 1908.

"It was at this low ebb in our furtunes," remarked Thorpe, glancing back at the 'forties, "that the Chemical Society was founded." Before that foundation in 1841, chemistry as a profession did not exist in Great Britain. In the words of Dr. W. J. Russell, "the number of real students in 1841 was very small. They were looked upon by their friends as being eccentric young men who would probably never do any good for themselves." This attitude by no means disappeared with the foundation of the Chemical Society.

(To be continued).

Coal Dust in Anthracite Mines.—Adequate ventilation and the liberal use of water sprays, it is concluded in a report on "Dust Problems in the Mines of the Pennsylvania Anthracite Region," are the most effective means of controlling the coal-dust problem in anthracite mines and of protecting the miners from contracting the respiratory disease known as anthracosilicosis. The report is the result of a three-year war-time survey made by the United States Bureau of Mines in 38 collieries in the Pennsylvania anthracite region. The report has been prepared by Mr. L. H. Johnson, who states that water reduces the amount of dust in the air of a mine by at least 80 per cent., and greatly improves illumination, while good ventilation prevents dust from collecting. Copies of the report (Technical Paper No. 704) are obtainable from the U.S. Government Printing Office, Washington 25, D.C., U.S.A., price 15 cents.

LABOUR NOTES.

At a meeting in London last week, the General Council of the Trades Union Congress approved the re-introduction of a Control of Engagement Order which, according to Mr. Attlee, is one of the steps which the Government proposes to take with the object of easing the economic crisis. In an official communication issued at the close of the meeting, it was stated that, as a first step, the Council "directs attention to the primary need for transference of labour from unessential and non-productive employment to those industries which are vital to the economic stability of the country. If it is found," it is added, "that the application of the Control of Engagement Order does not produce the results required, the General Council will be prepared to discuss with the Government further measures, including direction of labour, which may be necessary to deal with our national difficulties."

"The General Council," the communication stated, "further recommends that consultation should take place with the specific industries involved with a view to examining how far an extension of hours is imperative to contribute to the necessary increase in production, if exports are to be increased to an extent which will materially improve our present serious adverse trade balance."

The Government's suggestion that the miners should work half an hour extra on each day of the five-day week was considered by the executive committee of the National Union of Mineworkers, at a meeting in London last week. Preference was expressed for Saturday working instead of half an hour extra on each of five days. According to Mr. Lawther, the miners' leaders believe that Saturday working will meet the requirements of the Cabinet. Members of the union are, therefore, he said, to be advised to work not fewer than two Saturday shifts a month, beginning on the first Saturday in September. The length of the shifts and the payment for them are being jointly discussed by the National Coal Board and the National Union of Mineworkers, and a special delegate conference of the union is to be held on August 22 to consider the executive's recommendation.

The National Union of Mineworkers has asked its area committees to appoint representatives to undertake the task of persuading the men to work with Polish labour. Mr. James Bowman, vice-president of the union, is to co-operate with the National Coal Board in the selection of other foreign recruits for the pits. The National Coal Board have appointed four officers to meet servicemen at release centres and invite them to take up careers in the mining industry. Representatives of the Board and the union are to go to Ireland for the purpose of discussing the action of the Eire Government in withholding exit permits to Irishmen who have volunteered to work in British pits.

At an informal conference in London on Wednesday, last week, representatives of the National Federation of Building Trades' Employers and representatives of the National Federation of Building Trade Operatives considered the proposals on the subject of wages, made on July 17 by the Minister of Labour and National Service. Mr. Isaacs, it will be recalled, proposed an increase of 3*d*. an hour on the basic wage plus a bonus on work done which would enable an operative to add as much as 20 per cent. to his basic wage.

The original claim of the operatives was for a wage increase of 6*d*. an hour for craftsmen and an increase of 9*d*. an hour for labourers. The compromise was accepted in principle by the National Federation of Building Trade Operatives which decided to ballot its affiliated unions on it. The National Federation of Building Trades' Employers have now also, in effect, accepted it; it has been agreed by the negotiating committee to submit it to the national executive committee for "favourable consideration."

According to *The Monthly Digest of Statistics*, Britain's working population has fallen by 99,000 since the beginning of the year. The total of 20,170,000 at the end of May represented a fall of 40,000 during the month; but the number employed in industry rose by 49,000 during May. Only 30,000 went into manufacturing industries. Of 7,037,000 employed in manufacturing industries, 1,439,000 were engaged on orders for export; comparable figures for 1939 were 6,815,000 and 990,000. The number of insured workers, registered as unemployed at June 16, was 272,300, or 2 per cent. of the total number insured.

In the first six months of the current year, 1,224,500 workpeople in the United Kingdom received a total increase in weekly wages estimated by the Ministry of Labour and National Service to amount to 296,000*l*. In the corresponding months of 1946 there were net increases of about 1,800,000*l*. in the weekly full-time wages of 5,400,000 workpeople.

In the same period of six months, 972 stoppages of work due to industrial disputes were reported to the Ministry of Labour and National Service: 341,600 workpeople were involved and there was an aggregate loss of 1,316,000 working days. Of the stoppages, 615 were in the coal-mining industry; they involved 146,200 workpeople and resulted in an aggregate loss of 1,316,000 working days. In the shipbuilding industry, 281,000, and in the transport industry 459,000 working days, were lost through stoppages.

The general secretary of the United Patternmakers' Association discusses, in the *Trade Report* of his organisation, a question of "plaster work" which has, he says, given the executive council concern for a considerable time. It was reported to them from Bristol, he writes, that work in plaster which was used as a pattern to cast light metal discs for presses, was being made, and had, in fact, been made over a period of years, by craftsmen other than patternmakers, and that such craftsmen had been under the supervision of an Amalgamated Engineering Union patternmaker. It was further reported, it is added, that members of the United Patternmakers' Association had refused to tackle the work when it was first introduced on the ground that it was dirty, etc.

"The question assumed importance," Mr. Beard goes on, "when similar work was introduced into a firm in North London, and the fact that such a precedent has been created in Bristol prevented agreement being reached between the London firm and our members with the possibility of a dispute of first magnitude arising. It was, therefore, necessary that I should see this work." Having seen it, he is "satisfied that not only should the work be claimed by our members, but that it is similar to that which our light-casting members from day to day do when they strike up work in stucco or plaster. In fact, I introduced our light casting members to this kind of work in Lancashire some years ago. It should not be forgotten that our rules provide for membership of patternmakers in any material, and we should, therefore, stake our claim to all work which goes into the sand or is duplicated from a master part. Plaster work, work in patterncrete, or similar cement material for patterns or duplicating is patternmaking. If it is not suitable or acceptable work to some members, it is to others."

Mr. Beard's claim that all patternmaking in any material should be performed by members of the United Patternmakers' Association is also given prominence in his introduction to his organisation's annual report. "The development of metal patternmaking," he writes, "has found our members actually assisting craftsmen other than patternmakers to do our job. . . . In the mass-production industries particularly, patternmakers are setting out a new drawing from the standard drawing, adding the necessary contractions, taper, core-prints, etc., and even making provision for core-dryers and loose pieces. This new drawing is then sent to the toolroom and the patterns and core-boxes are made by tool and precision fitters. True, our rates are probably being paid, but the fact remains that members of other unions are doing it. It would, obviously, be impossible for the work to be done without the assistance of the patternmakers in the first instance."

"There is also," Mr. Beard continues, "the question of pattern filing and similar work, which requires the attention and supervision of the patternmaker. The work is not so skilled, but the men doing it should obviously be organised by us to prevent encroachment on our trade, but to do so would require special provision in our rules. This, then, is a subject for branch discussion and consideration. We obviously cannot base our organisation on past practices; we must move with the times. . . . . Mass production is increasing, and, with it, the production of metal or plastic patterns, core-boxes and equipment. Let us then face facts clearly. We cannot prevent this development, even were it advisable, which it is not; so, obviously, we must organise it."

In 1946, the gross income of the United Patternmakers' Association was 82,923*l*. 3*s*. 1*d*., and the gross expenditure 64,158*l*. 7*s*. 10*d*. In the previous year, the gross income was 78,710*l*. 6*s*. 3*d*. and the gross expenditure 58,446*l*. 12*s*. 7*d*.

MEMORIAL TO TIMOTHY HACKWORTH.

FIG. 1. MEMORIAL TABLET.

FIG. 2. HACKWORTH'S COTTAGE AT NEW SHILDON.

MEMORIAL TO TIMOTHY HACKWORTH.

THE preface to Robert Young's well-known book on *Timothy Hackworth and the Locomotive* expressed "the hope that, even in these days of easy forgetfulness, the achievements of a modest and unambitious man may not pass into oblivion." At that date (1923), in spite of the popular interest in railways and the fact that the centenary of the opening of the Stockton and Darlington Railway, for which Hackworth did so much, was only two years ahead, the author was obliged to note, with justifiable regret, that, although "New Shildon was once the nursery of the locomotive," it showed "not a sign that here were built some of the most famous engines of early days, nor that Timothy Hackworth their designer and builder lived and worked here for 25 years." There was, of course, Hackworth's tombstone in Shildon churchyard, and a drinking fountain in the park, bearing a crude representation of the "Royal George" of 1827—the first six-coupled engine to have outside coupling rods; but, as Young wrote, "Hackworth's house is now divided into cottages, nor is there anything to remind the visitor of the distinguished man who once lived there."

This stigma, however, and the somewhat exaggerated complaint that, by the time that the North Eastern Railway absorbed the Stockton and Darlington Railway in 1863, "the policy of blotting out such historic interest as Shildon possessed had been fully accomplished," have been alike corrected by the North Eastern's successors, the London and North Eastern Railway; for the memorial plaque illustrated in Fig. 1, herewith, has been mounted recently on the front garden wall of Soho Cottage, as Hackworth called the house which he made a focus of the industrial and social life of the town until his death on July 7, 1850.

The Soho Works—so called on the suggestion of Joseph Pease, though the reason is not obvious—stood behind the house, and in front was the Stockton and Darlington Railway, of which Hackworth was superintendent of "the permanent and locomotive engines" from its opening in 1825 until 1840, when he decided to set up in business as a builder of locomotives and other machinery for all and sundry. The railway company eventually acquired the property from his executors in 1855, according to a footnote in Young's book, referred to above. At the time of Timothy Hackworth's death, his son, John Wesley Hackworth, was manager at the Soho Works, but he relinquished this position to set up a new works of his own in Darlington. There he built horizontal engines of original design, which he advertised in the first issue of ENGINEERING, dated January 5, 1866.

The plaque, of cast bronze, forms a dignified reminder of an engineer whose services in the development of the locomotive are often overlooked; but the position, on a low garden wall, as shown in Fig. 2, is a direct incitement to the juveniles of Shildon to pick out the lettering in coloured chalk, as happened to Henry Maudslay's tomb at Woolwich when the protecting railings were removed as "salvage" during the war: in fact, the photograph from which Fig. 1 was prepared shows clearly that this had been done already.

NOTES ON NEW BOOKS.

The Calculation of Heat Loss from Steam Pipes. By H. BUCKLEY, A.M.Inst.Gas E., M.Inst.Fuel. Emmott and Company, Limited, 31, King-street West, Manchester, 3. [Price 2*s.* 6*d.* net.]

THIS booklet, No. 33 of the "Mechanical World Monographs" series, will appeal chiefly to the maintenance engineer in charge of a medium-pressure steam plant. The opening chapter is devoted to the familiar calculations of heat losses caused by conduction, radiation and convection; the procedure is discussed step by step, the figures and formulæ given being easy to follow and requiring only an elementary knowledge of mathematics. A medium temperature range of from 200 deg. to 600 deg. F. is adopted as a basis, and the data cannot be applied to temperatures outside these limits with any accuracy; and, within the specified limits, there may be considerable variation according to the conditions under which the plant operates. The losses calculated in accordance with the instructions given are to be regarded as average, therefore, and due allowance must be made to offset any extreme conditions. In subsequent chapters, insulating materials and charts for calculating purposes are discussed, and the application of the charts for the determination of heat losses is fully explained. Separate charts are given for heat transmission by conduction, heat loss by radiation, and heat loss by natural convection. In the closing chapter Mr. Buckley discusses the use of insulating materials from the economic standpoint.

Materials of Industry: Their Distribution and Production. By S. F. MERSEREAU. Fourth edition, revised by PROFESSORS CALVIN G. REEN and KENNETH L. HOLDERMAN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York, 18, U.S.A. [Price 2.80 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, London, W.C.2. [Price 14*s.*]

EVERY engineer aims to know everything of something, and, to be well-informed, he should know something of everything in his own line. In the latter respect, this volume will be a source book for him, although each reader will find omissions. The materials are classified under Forest Products; Non-metallic Minerals; Iron and Steel; Non-ferrous Metals; and Miscellaneous, to each of which a chapter is devoted. The two categories last mentioned together occupy about as much text as each of the others. The volume is intended primarily for students, and the course of study recommended—that of the Brooklyn Technical High School—is by the presentation of just sufficient historical facts to give the background to the present state of industry; by practical work, and by demonstrations, assisted by visual aids. A list of films suggested for this purpose is given in each chapter, and from surprisingly varied sources. To each chapter also a bibliography is appended, confined, however, to United States publications. The chapter on iron and steel would be more incisive if its sub-division recognised that there are three main periods to be covered: namely, the direct or bloomery process, lasting some 5,000 years, the product being wrought or weld iron; blast-furnace process, covering a mere 450 years, with cast iron as the product; and, emerging from the latter within the past century, ingot iron or mild steel processes, with their congeners. There is much in this volume to give food for thought to engineering educators.

The End of the Chapter, 1939-1945. Thos. W. Ward, Limited, Albion Works, Sheffield.

THIS interesting account of their proceedings between 1939 and 1945, which has been prepared by Messrs. Thos. W. Ward, Limited, records activities extending over a broad and varied field. First place is given to the matter of scrap iron and steel. The handling and distribution of scrap being one of the everyday activities of the Ward firm, they were naturally closely connected with the operation of the campaign for the collection and sorting of scrap from all possible sources. The cutting-off of supplies from abroad, which had amounted to about three-quarters of a million tons annually, had the result that, owing to increased demand, a million extra tons had to be found inside the country each year. The firm recovered much material from damaged buildings and were actively engaged in shipbreaking. A description is given of the attempt made to recover scrap from six German submarines which had been lying on the rocks in Falmouth Bay since 1920. Ultimately two were beached, but work on the remainder was abandoned in 1944, owing to the sowing of German mines. Possibly the most novel constructional work dealt with in the volume is the building of midget submarines by Marshall, Sons and Company, of Gainsborough, an associated firm, who, however, maintained their more usual lines of manufacture by constructing, for instance, 600 road rollers for work on aircraft landing fields.

An Introduction to Heat Engines. By PROFESSOR E. A. ALLCUT. Second edition. The University Press, Toronto, Canada; and Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 16*s.* net.]

THIS book, first published in 1943, provides a general survey of heat engine practice and explains, without going into too much theoretical detail, the fundamental principles underlying the operation of all types of heat engine. The first three chapters, dealing with the relation between heat and work, working fluids and their properties and thermal cycles, are followed by a survey of the historical development of heat engines. Fuels and principles of combustion, problems relating to heat transmission, and the design and arrangement of pipes, ducts and manifolds are dealt with. Thermal and mechanical losses that have no connection with the thermal cycle form a separate chapter, and various types of valves and valve motions are described. The last two chapters deal with the testing and economy of heat engines and their accessories. The absence of numerical examples lessens the utility of the book as a text-book for examination purposes. It is, however, one which can be read with advantage by students and others who require a good general description of the various branches of heat-engine practice.

GRAPHITE FORMATION IN CAST IRON.

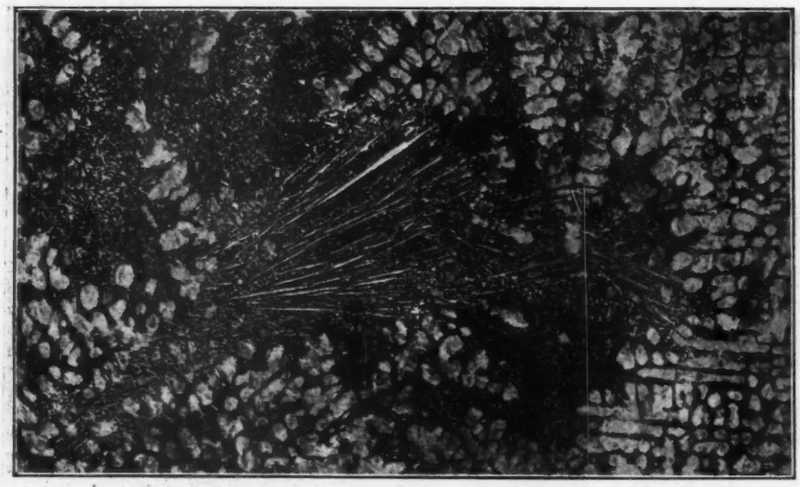


Fig. 8. Inverse Chill in Iron With Undercooled Graphite. × 60.

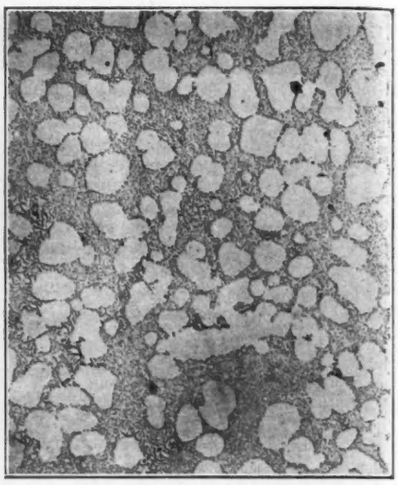


Fig. 9. Nickel-Carbon Alloy. × 60.

GRAPHITE FORMATION IN GREY CAST IRON.*

By H. Morrogh and W. J. Williams, B.Sc.

(*Concluded from page* 143.)

In the preceding section an illustration has been given of the inoculating effect of graphite. That this phase should cause inoculation of the melt is not surprising and the solution of graphite nuclei has been suggested as the mechanism responsible for the production of undercooled graphite by superheating. This idea has received support by some investigators, but it has also been shown that graphite dissolves very readily, even at relatively low temperature in hypo-eutectic irons. Additions of graphite to a melt immediately before pouring have a powerful chill-removing influence. As an elaboration of the graphite-nuclei theory, it has been suggested that the function of calcium silicide and ferro-silicon in inoculating a melt is the production of momentary local concentrations of silicon which cause the precipitation of kish graphite, the persistence of which is ultimately responsible for the nucleation of the melt.

The present investigators wish to point out that this theory should indicate any element which reduces the carbon content of the eutectic to have an inoculating influence. Phosphorus, for instance, has roughly the same influence as silicon on the carbon content of the eutectic, but after many attempts the present investigators have been unable so far to produce inoculation by an addition of phosphorus or ferro-phosphorus.

The influence of sulphur in cast irons is probably very complex, and reference can only be made to the general trends in the observed influence of this element. Boyles has shown that cast irons differ fundamentally from simple ternary iron-carbon-silicon alloys of otherwise high purity, in that the latter usually give undercooled structures as a general occurrence. This experimental evidence indicates that the sulphur in cast irons may be responsible for the frequent formation of flake graphite in cast irons.

Norbury and Morgan demonstrated that treatment of a melt with hydrogen resulted in coarse flake graphite. The effect of hydrogen could be eliminated by subsequently bubbling carbon dioxide through the melt and furthermore it was found that the influence of hydrogen would disappear by holding the metal molten for a lengthy period after treatment with this gas. These findings were largely confirmed by Boyles, who was also able to confirm the findings of previous investigators that melting in a vacuum gave undercooled graphite structures in hypo-eutectic irons and that the same structures could be obtained by melting in carefully dried air or nitrogen. No satisfactory explanation has yet been produced for the influence of these gases upon the graphite structure of cast iron.

A considerable advance in the understanding of the mechanism of the formation of undercooled graphite was made when Eash demonstrated that this form of graphite resulted as the solidification of white iron, the cementite of which decomposed after solidification. This investigator confirmed the finding of Boyles that flake graphite originating from the eutectic formed directly from the liquid metal. The present investigators considered the findings of Eash to be sufficiently important to check, using somewhat different experimental procedure, and at this stage it can be said that complete confirmation was obtained, as will be seen later.

Frequently, castings are obtained which on fracturing show specks of white iron in the central zones of the fracture; this is usually described as inverse chill. This phenomenon is counter to normal experience, in that the carbide persists in the portions cooled more slowly, whereas carbide is usually obtained in the more rapidly cooled parts of a casting. This phenomenon should not be confused with that which is obtained when the sand mould causes inoculation of the surface layers of an otherwise white iron casting. The former appears to occur only when the grey portions of the casting have undercooled graphite structures.

Fractures showing this inverse chill give the impres-

* Communication from the British Cast Iron Research Association, presented at the 44th annual meeting of the Institute of British Foundrymen, held at Nottingham from June 17 to 20, 1947. Abridged.

Fig. 10. Fragmented Hyper-Eutectic Graphite. × 60.

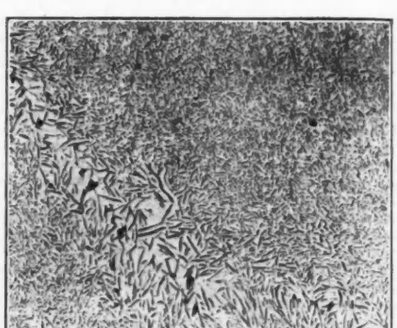


Fig. 11. Fine Eutectic Graphite. × 60.

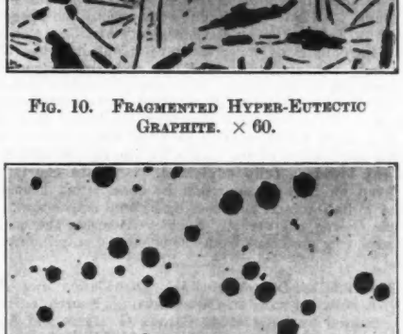


Fig. 12. Spherulitic Graphite in Hyper-Eutectic Nickel-Carbon Ingot. Unetched. ×60.

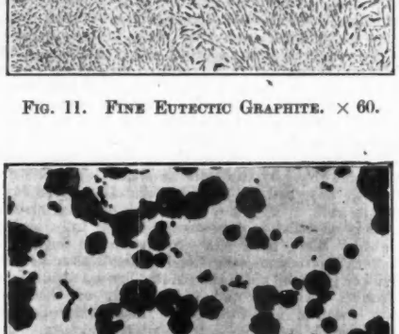


Fig. 13. Segregation of Spherulites. Unetched. × 60.

GRAPHITE FORMATION IN CAST IRON.

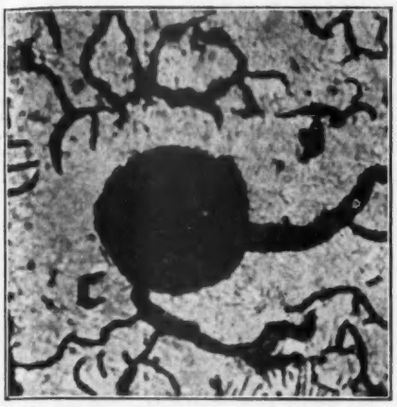


FIG. 14. SPHERULITE OF HYPER-EUTECTIC GRAPHITE. ETCHED IN PICRIC ACID. × 1,500.

FIG. 15. SPHERULITES OF GRAPHITE WITH INVERSE CHILL. ETCHED IN PICRIC ACID. × 60.

sion at first that the spot of white iron is an undissolved alloy addition. Examination under the microscope has revealed that the white iron of inverse chill possesses characteristic and easily recognisible features. Fig. 8, opposite, illustrates the typical appearance of the microstructure of inverse chill, and it will be clearly seen that the carbide is arranged in an acicular pattern differing considerably from the normal eutectic structure of white cast iron. It will be shown later that this observation can be linked with the findings of Eash upon the mode of formation of undercooled graphite.

Eash determined the cooling curves on bars 6 in. long and 1·2 in. diameter, cast in dry-sand cores with thermocouples inserted in the mould cavities. At the appropriate temperature after solidification the cores were broken open and the bars were quenched in water. This method obviously calls for considerable dexterity and the accuracy of fixing the actual quenching temperature is limited partly by the relatively rapid cooling rate of such relatively small sections. After many attempts to develop a satisfactory alternative technique, the present investigators finally used samples weighing about 6 grammes melted in small crucibles made of silica tubing. The melting and cooling was carried out in a platinum-resistance tube furnace, arranged so that immediately after the completion of solidification the silica tube assembly could be plunged through the furnace bottom into a deep bath of water. The cooling rates used were equivalent to those obtained in sections greater than 3 in. when cast in sand moulds. The occurrence of undercooled graphite was made certain by the use of irons containing titanium. Medium and low-carbon irons were investigated.

Preliminary experiments showed that good undercooled graphite structures were obtained when the ingots were allowed to cool slowly to room temperature. Ingots quenched immediately after solidification had a white iron structure.

It is important to recall that, when considering undercooling as exemplified by the system betol-salol, it was tacitly assumed that the binary complex solidifying at the hypertectic point on the super-solubility curve consisted of a mixture of the compounds betol and salol, and that these formed directly from the liquid without the intermediate formation of a metastable compound. Now the work of Eash showed that undercooling in cast irons occurs by a different mechanism and that undercooled graphite does not form directly on solidification from supersaturated liquid. The present investigators were impressed by this point, and the question arose whether the type of undercooling found in iron-carbon-silicon alloys was unique or whether a similar process occurred in other alloys. It was therefore decided to investigate two other series of alloys to throw light on this subject.

When we have two metallic elements A and B and a third C, there is frequently considerable analogy in the binary systems A-B and A-C when the elements B and C come from the same group in the periodic table or come from the same period of transitional elements. To compare with iron-carbon or iron-carbon-silicon alloys we have two extremely useful systems in nickel-carbon and cobalt-carbon alloys. The elements iron, cobalt and nickel are neighbours in the first long period and in this period they are the last three transitional elements. The atomic numbers are 26, 27 and 28 and their atomic weights are 55·85, 58·94 and 58·69, respectively. These three elements all give alloys with carbon depicted in equilibrium diagrams of great similarity. The systems are all eutectiferous, involving a eutectic of graphite and a solid solution of carbon in the metal. The crystal structure of the solid solution is probably the same in each case—face-centred cubic with interstitial carbon. The liquidus on the metal-rich side of this eutectic indicates the primary deposition of this solid solution from the melt and on the carbon-rich side it indicates the deposition of graphite from the melt. In all three systems the solubility of carbon in the solid solution decreases with decreasing temperature.

The present investigators have studied graphite formation and undercooling in nickel-carbon and cobalt-carbon alloys, but only the general results of the experiments will be presented here. Both hypo- and hyper-eutectic nickel-carbon alloys were studied* and it was found that, in the absence of other elements, the hypo-eutectic alloys gave structures resembling those of undercooled graphite in hypo-eutectic cast irons. A typical example is shown in Fig. 9, opposite. In hyper-eutectic alloys, long straight flakes of hyper-eutectic or "kish" graphite were obtained, together with eutectic graphite in an undercooled form. When hyper-eutectic nickel-carbon alloys were melted in graphite crucibles and allowed to cool slowly, the hyper-eutectic graphite tended to float out, giving structures similar to those shown for cast irons in Figs. 5, 6 and 7, on page 143, *ante*. A typical example of the fragmented hyper-eutectic graphite at the top of such an ingot is shown in Fig. 10, opposite, while Fig. 11 shows the fine eutectic graphite in the central zones of the ingot from which the graphite had floated. Obviously, hyper-eutectic graphite in nickel-carbon alloys can inoculate the eutectic to give flake graphite.

The addition of sulphur to nickel-carbon alloys was found to give normal flake graphite structures exactly similar to those obtained in cast irons. In the absence of manganese, sulphur exists in nickel-carbon alloys as Ni_3S_2, and in the presence of manganese as MnS. It was found that sulphur gave the coarse flake structures regardless of its mode of occurrence. In this context it is interesting to recall the findings of Boyles, mentioned earlier, that cast irons and iron-carbon-silicon alloys tended to give undercooled graphite structures unless sulphur was present.

Examined at high magnifications under polarised light, the graphite flakes in nickel-carbon alloys had the same optical properties and orientations as described earlier for graphite flakes in cast irons. Furthermore, at high magnifications under polarised light the same complex internal structures were found in the graphite flakes.

Various inoculation experiments were tried on nickel-carbon alloys and a remarkable result was achieved when calcium silicide was used for this purpose. This addition was found to cause the graphite to occur in perfectly-formed spherulites, particularly when the alloy was slowly cooled. The same result was obtained whether the alloy was hypo- or hyper-eutectic in composition. Fig. 12, opposite, shows the spherulites of graphite obtained by treating a nickel-carbon ingot melted in a graphite crucible. This micrograph was taken in the central portion of the ingot from which the hyper-eutectic graphite had floated to the top. The hyper-eutectic graphite was also produced in a spherulitic form and the spherulites tended to float to the tops of such ingots. A typical example of a segregation of spherulitic hyper-eutectic graphite at the top of an ingot is shown in Fig. 13, opposite. At high magnifications these spherulites produced by calcium-silicide additions were found to have a structure identical with that found in spherulites in malleable cast iron and to have the same crystallite orientation as described previously. At the time this discovery appeared to indicate a unique feature of nickel-carbon alloys.

It was subsequently found that the production of graphite spherulites was not a special feature of calcium silicide alone, but that any alloy or compound, the use of which would give calcium alloyed with the nickel-carbon alloy, would also give spherulitic graphite. Furthermore, it was found that the elements barium, strontium and magnesium had an effect similar to that of calcium. The production of spherulites in nickel-carbon alloys was not obtained when a prior addition of sulphur was made. In this respect sulphur had the same effect whether present as Ni_3S_2 or as MnS. The fundamental reason for this has not yet been elucidated. Rapid cooling from the liquid state, air-cooling or water quenching, also gave nodular structures. The spherulites produced by rapid cooling were not perfect in outline, but the typical radial spherulitic structure was always present. The presence of sulphur also prevented the formation of spherulites by rapid cooling.

Cooling-curve studies were made on nickel-carbon alloys and it was found that the eutectic temperature was the same for alloys giving the undercooled structures as for the alloys giving spherulitic structures by calcium-silicide additions. This temperature was 1,325 deg. C. ±1. Originally, some difficulty was experienced in producing coarse-flake graphite structures without an addition of sulphur, but when a suitable inoculation technique was developed which did not cause an addition of sulphur, the eutectic arrest was found to be at least 10 deg. C. higher for flake graphite structures. Sulphur probably lowers the freezing point of the eutectic in nickel-carbon alloys. Obviously, undercooling is possible in nickel-carbon melts and the formation of graphite spherulites is related to undercooling. This latter point is indicated by the eutectic arrest temperature and by the effect of rapid cooling in producing spherulitic structures.

Experiments were carried out in which slowly cooled, but otherwise untreated, nickel-carbon alloys were quenched into water immediately after solidification. Alloys allowed to solidify under the same conditions and allowed to cool slowly to room temperature give undercooled graphite structures, but those cases in which the alloys were quenched immediately after solidification had fine spherulitic structure. This indicated that undercooled graphite structures in nickel-carbon alloys are produced by the solidification of a metastable eutectic which subsequently decomposes after solidification. It has since been possible to demonstrate that this eutectic consists of the solid solution and nickel carbide, which, being very unstable, decomposes even on rapid quenching to give nodular structures. It has been possible also to show that the function of calcium, magnesium, strontium and barium in producing nodular structures is to permit undercooling and the solidification of the nickel carbide, the decomposition of which is retarded and so gives spherulitic structures instead of the typical undercooled structures. Rapid cooling has a similar

* In all cases these alloys were made by dissolving electrode carbon in pure nickel.

effect in preventing the decomposition of the nickel carbide until a lower temperature is reached.

The influence of calcium-silicide additions upon the graphite structure in nickel-iron-carbon alloys was also investigated, and it was found that this addition caused the formation of graphite spherulites in all alloys with less than about 49 per cent. iron. With higher iron contents than this, calcium silicide additions had the normal effect of producing flake graphite structures.

In all the respects outlined above, cobalt-carbon alloys tended to behave very similarly to the nickel-carbon alloys, but evidence was obtained of the greater stability of cobalt-carbide compared with that of nickel-carbide. Eutectic cobalt-carbide was obtained by rapid quenching from the liquid, whereas nickel-carbide was only obtained in a fine Widmannstätten pattern by the same treatment. Additions of calcium to cobalt-carbon alloys did not give nodular structures, but magnesium was always effective in this respect. These points clearly indicate the properties of cobalt-carbon alloys to lie midway between those of iron-carbon and nickel-carbon alloys.

In view of the marked general similarity of nickel-carbon and cobalt-carbon alloys on the one hand, and the iron-carbon-silicon alloys on the other, and in view of the production of spherulitic graphite in the former, it was argued that there was a high degree of probability that spherulitic structures could be similarly produced in iron-carbon-silicon alloys or cast irons. To determine whether this was so, a search was made, and it was discovered that nodular or spherulitic graphite could be produced in cast irons in isolated cases in small areas of the microstructure when conditions of composition, prior treatment, and cooling rate lent themselves to extensive undercooling.

It was found that hyper-eutectic graphite was obtained in this form more readily than eutectic graphite. A typical example of spherulitic hyper-eutectic graphite is shown in Fig. 14, on page 167. The iron from which this micrograph was taken had the following composition: total carbon, 3·91; Si, 2·83; Mn, 0·62; S, 0·021; and P, 0·10 per cent.

If a careful study is made of Fig. 7, on page 143, *ante*, it will be seen that some nodules of hyper-eutectic graphite are present again in a hyper-eutectic sample in which undercooling has occurred. A careful examination of many samples has also revealed that spherulitic nodules tend to be associated with inverse chill in specimens which also contain undercooled graphite. This is illustrated in Fig. 15, on page 167, which shows spherulites of graphite associated with inverse chill at the centre of the section of a hypo-eutectic cast iron containing undercooled graphite; here the acicular structure of the carbide of the inverse chill is again apparent. In normal cases of inverse chill the carbide is stable right down to room temperature, but occasionally it decomposes after solidification, at a temperature lower than that required to give undercooled graphite, with the formation of spherulites.

CATALOGUES.

Switch-Fuses.—Messrs. Cantie Switches, Limited, Northgate Works, Chester, have issued a booklet entitled "The Application of Switchfuses," in which the major technical considerations relative to safe and economical application of this form of protection of electrical circuits are reviewed. The basic features of design are outlined and reference is made to the types of fuses available.

Panel Heating.—We have received from Messrs. Richard Crittall and Company, Limited, 156, Great Portland-street, London, W.1, an informative and handsomely-illustrated booklet describing their system of low-temperature panel warming as applied to different methods of floor construction. The heating is effected by radiation from the lower surface of the floor, which is, of course, the ceiling of the room below.

Radar Marine-Navigation Equipment.—Two leaflets recently issued by Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, deal with the Seascan Radar system, which the firm have developed for use in the mercantile marine. This system was fully described in ENGINEERING, for July 26, 1946, on page 79. The leaflets give details of its utility in practice, both in narrow waters and in foggy conditions.

Batteries for Rail and Air Service.—A handsomely illustrated booklet, issued by the Chloride Electrical Storage Company, Limited, Whitfield House, Whitfield-street, London, W.1, deals with the Exide-Ironclad batteries used on the royal train in South Africa for supplying the lighting and telephone systems. For re-charging the batteries in outlying places 12 mobile petrol-electric sets were provided and these were also fitted with Exide batteries for starting. In addition, the four Vickers Viking aircraft which formed the King's Flight were equipped with Exide batteries for supplying all the electrical services.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

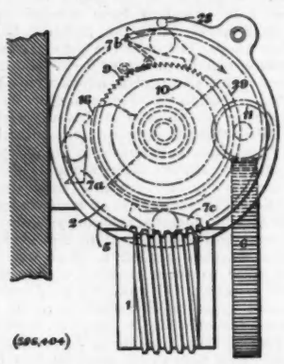
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

TEXTILE MACHINERY.

586,404. Sliver-Drawing Machine. James Mackie and Sons, Ltd., of Belfast, and J. P. Mackie, of Belfast. (5 *Figs.*) December 22, 1944.—The invention is an adjustable bell mechanism for use with machines drawing fibres into slivers. Its special feature is that the length of yarn delivered can be altered, according to whether light or heavy slivers are being produced, without changing gear wheels or stopping the machine, as has hitherto been necessary. A worm 1 driven from the drawing machine rotates a worm wheel 2 mounted on a spindle supported by a fixed casing 5. The worm wheel 2 carries a single pawl, shown in three different positions, 7*a*, 7*b* and 7*c*, the pawl being pivoted on a stud fixed to the worm wheel 2. The pawl intermittently drives a ratchet wheel 9 freely mounted on the spindle and carrying a gear wheel 10 in mesh with a pinion 11 which is geared to the pin wheel 6. The latter wheel operates the mechanism for ringing a bell. The operating tip of the pawl is spring loaded towards the ratchet wheel 9. The period during which it engages the ratchet wheel 9 is determined



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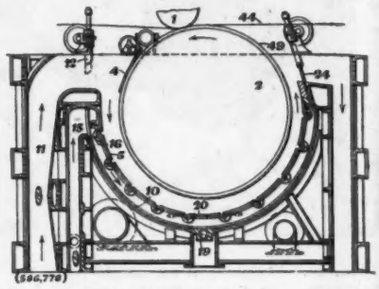
by the positions of two arcuate shields 16 and 29. When the pawl is in the position 7*a* its operating tip rests on the edge of the arcuate shield 16. As soon as the pawl has rotated clockwise far enough for the tip to become clear of the shield 16, it engages the teeth of the ratchet wheel 9 and carries the latter forward. The position of the pawl is then as shown at 7*b*. The pawl continues to engage the ratchet wheel 9 until its tail engages the projection 28 on the casing 5, thus lifting the operating tip from the ratchet wheel 9, which stops rotating. By the time the tail end of the pawl has cleared the projection 28 the forward tip of the pawl is in position to drag on to the second shield 29, which has a slightly greater radius than the shield 16. The operating tip of the pawl ultimately drops on to the shield 16 from the shield 29. The shield 16 is carried on an arm, so that it can be rotated to cover any desired portion of the exposed teeth on the ratchet wheel, thus varying the amount by which the pin wheel 6 rotates for every revolution of the worm wheel 2. This adjustment can be made without stopping the machine. (*Sealed.*)

MISCELLANEOUS.

586,778. Papermaking Machine. Walmsleys (Bury), Limited, of Bury, Lancashire, and J. Temperley, of Bury, Lancashire. (6 *Figs.*) October 18, 1944.—The machine is one in which paper pulp is deposited on a rotary hollow perforated drum in a stock vat. The object of the invention is to control the deposition of the pulp on the drum and to enable the characteristics and amount of the deposition to be varied as desired. The cylinder mould is a hollow perforated drum 2 covered with wire 49 and immersed in a vat. It rotates anti-clockwise, the wire 49 being partly shrouded by an adjustable mould apron 4. A continuous pick-up felt 44 passes under a couching roller 1 on to the surface of the wire-covered drum 2. The vat has a false-bottom floor 5 interrupted by controllable valves 8 in the space between the false-bottom floor 5 and the bottom wall 10 of the vat. Pulp stock fed by a pump passes up the main stock-inlet conduit 11 and under an adjustable dam 12, and thence down over the mould apron 4 on to the making wire supported by the drum 2. Subsidiary streams of pulp stock are fed from the same pump up a supply conduit 15 and down into the space between the false-bottom floor 5 and the bottom wall 10 of the vat, to emerge therefrom through the valve openings tangentially to the main flow of pulp stock in the space



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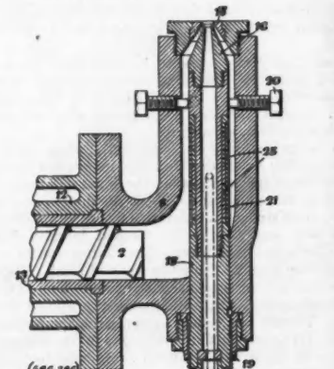
between the false-bottom wall 5 and the making wire on the drum 2. Each of the valves 8 is adjustable and extends right across the width of the vat-supported at spaced intervals by fins 16 extending laterally from longitudinal partition walls dividing up the area across the vat into a number of peripheral cells to ensure evenness of flow of the stock. The valves are streamlined so that the auxiliary streams enter the main stream tangentially and with the minimum of disturbance and eddies. A dump valve 19 in the bottom wall 10 of the vat is used in conjunction with dumping doors 20 hinged between the spindles for the two lowermost valves. Overflow from the vat is controlled by an overflow slice 24 operated by worm and worm-wheel gearing. (*Accepted* March 31, 1947.)

586,386. Cable-Extrusion Machine. British Insulated Cables, Limited, of Prescot, Lancashire, J. L. Packer, of Liverpool, and H. M. Steward, of Liverpool. (1 *Fig.*) January 17, 1944.—The machine is one in which a wire core is covered by extruded thermo-plastic material. The material is heated by subjecting it to the action of a high-frequency electric field. A frequency of 10 to 30 megacycles per second and an operating voltage of 1,000 to 2,000 are used. The machine consists of a jacketed cylinder 12 fitted with a smooth bored sleeve 13 in which the feed screw 2 is a working fit. The thermo-plastic cable cover is driven forward by the screw 2. On the front end of the cylinder is mounted a side-delivery head 8 containing an extrusion chamber, which sweeps round at a right angle, so that its outlet end lies with its axis at right angles to the cylinder. An outer



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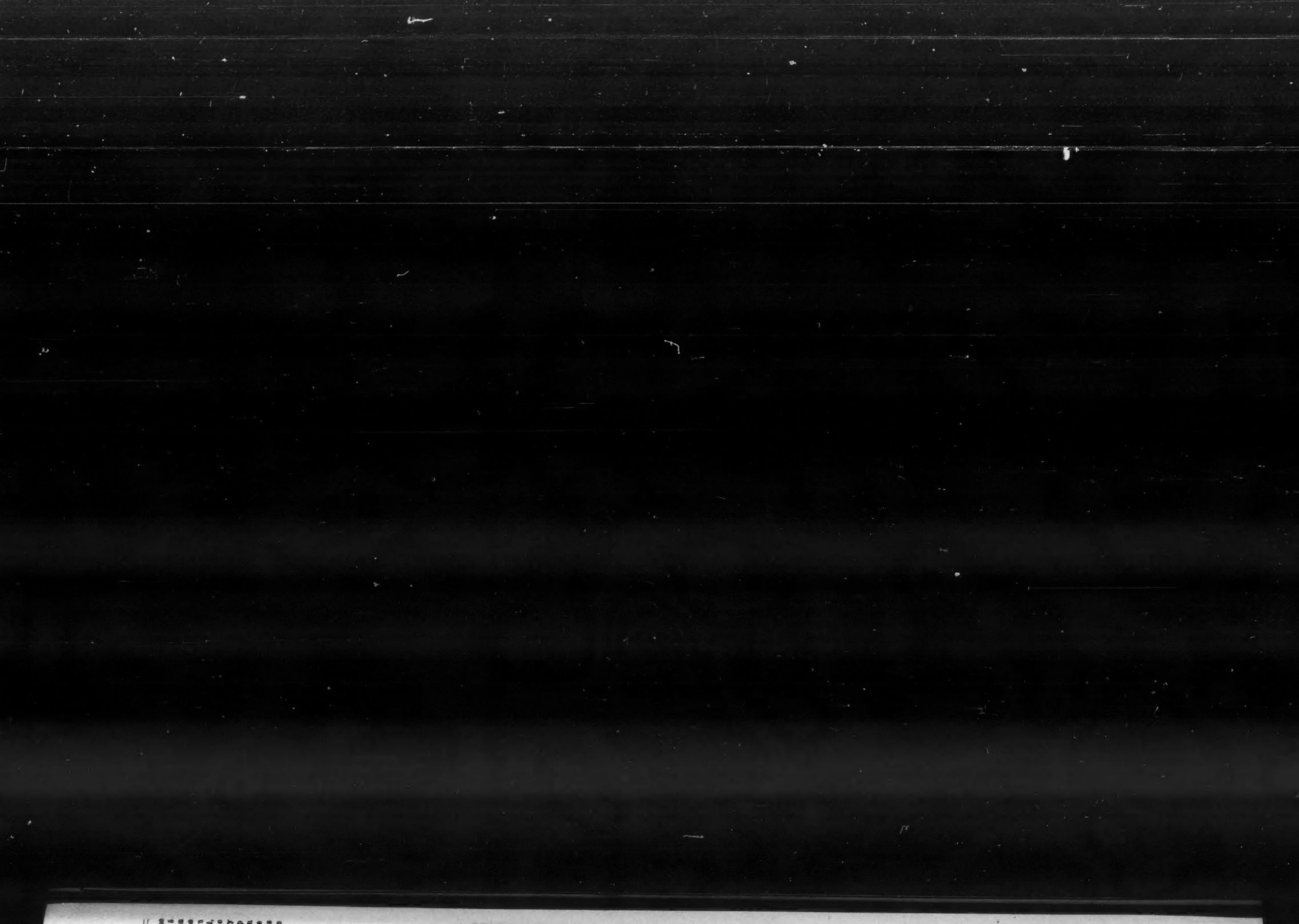
die 15 and the hollow inner point 16 define an annular extrusion orifice at the delivery end of the extrusion chamber. The point 16 is carried on a point holder 18 mounted in the wall of the head so that its axial position may be adjusted to a limited extent by rotation of the nut 19. Limited lateral adjustment of the point holder is obtained by four set-screws 20. The core to be covered is drawn through the point holder. The insulated high-tension electrode of the heater consists of a metal sleeve 21 mounted on an insulating liner built up of ceramic rings 25, the other electrode being formed by the wall of the head. The feed to the electrode 21 is by a cable 40, which passes through the upper part of the bore of the point holder 18, leaving sufficient room also for the passage of the wire to be covered. (*Sealed.*)